Engineering Library

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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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VOL. CXII.—No. 2902.] *LONDON: FRIDAY, AUGUST 12, 1921.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 4d.

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See Advertisement last week, page 101.

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Specification and Workmanship equal to Main Line Locomotives.
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For Paraffin and Crude Oil.
Sizes 2½ B.HP. and upwards.
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PADDLE OR SCREW STEAMERS OF EXCEPTIONAL SHALLOW DRAUGHT.
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designed and constructed by
MANNING, WARDLE AND COMPANY, LIMITED,
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See Illustrated Advertisement Page 160, Jan. 28.

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See Advertisement page 50. 9091

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WORK of all descriptions undertaken for Manufacturers, Patentees, &c. Also repairs and renewals. Best work, moderate charges.—ROSSEN & RUSSELL, LTD., Queen's Wharf, Hammersmith.
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MANUFACTURERS OF
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FEED WATER HEATERS,
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SYPHONIA STEAM TRAPS, REDUCING VALVES
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Matthew Paul & Co., Ltd.
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See Full Page Advt., page 67, July 22.

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Walter Somers, Limited,
HALESOWEN. 7116

Head, Wrightson & Co.,
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See Advertisement page 69. 3402

Taylor & Challen Presses 3196
LARGE STOCK of NEW PRESSES now on view in our Showrooms, Constitution Hill.
TAYLOR & CHALLEN, LD., Engineers, BIRMINGHAM.
See Full Page Advertisement page 71, July 22.

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E. P. Alexander & Son,
CHARTERED PATENT AGENTS,
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Universal and Cutter Grinding MACHINES IN STOCK. Suitable for accurate internal and external grinding, surface grinding, and all kinds of cutter grinding. High Speed Hack Sawing Machines, 6 in. capacity.
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(ELECTRIC). 9036
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"Spencer-Hopwood" Patent Boilers. *See page 83*
Sole Makers:
SPENCER-BONNECOURT, LTD., 9062
Parliament Mansions, Victoria St., London, S.W.

Centrifugals.
Pott, Cassels & Williamson,
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See half-page Advertisement, page 81, August 5.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.

Chief Engineer: C. B. STROMEYER, M.I.C.E.

Founded 1854 by SIR WILLIAM FAIRBAIRN.

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University of Birmingham.

DEPARTMENT OF METALLURGY.

Professor:—THOMAS TURNER, M.Sc., A.R.S.M., F.I.C.
Lecturer:—DOUGLAS H. INGALL, M.Sc.
Assistant Lecturers and Demonstrators:—T. G. BAMFORD, M.Sc.; HAROLD HARRIS, B.Sc.

The course of study covers three years, and leads to the Degree of B.Sc. in Metallurgy. There are separate courses for Metallurgists and Metallurgical Chemists.

Special attention is devoted to Iron and Steel; Copper, Brass and Local Industries; and to preparation for Colonial and Foreign posts.

Research and other Scholarships.

For particulars apply to:—
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Secretary. R 575

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as usual last Exam. by Correspondence Coaching. Successes by hundreds, several prizes. Sec. "O" embraces 26 years' professional experience. Address, 7434, Offices of ENGINEERING.

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Up-to-date Tuition for

Inst. C.E., I. Mech. E., and other Exams. by LONDON Expert, over 30 years' experience, honours, degrees, gold medals. NO FAILURES, moderate terms.—Address, R 731, Offices of ENGINEERING.

TENDERS.

STONE URBAN DISTRICT COUNCIL.

TO ENGINE BUILDERS.

The above Council invite

Tenders for the Provision and

Erection of a STEAM PUMPING ENGINE, of about 30 B.H.P., at their Waterworks.

Specifications and Form of Tender may be obtained from Mr. R. C. FRAIN, M.I.C.E., 30, Albion Street, Hanley, Stoke-on-Trent, on payment of £1, which will be returned on receipt of bona-fide Tender.

Tenders, endorsed "Tender for Engine," must be received by me, the undersigned, on or before Saturday, 20th August.

The Council do not bind themselves to accept the lowest or any Tender.

CHARLES H. MATTHEWS,
Clerk to the Council.
Westbridge House, Stone, Staffs,
30th July, 1921. R 636

VENTNOR URBAN DISTRICT COUNCIL.

REPAIRS TO TIE RODS, &c., TO THE ROYAL VICTORIA PIER AND LANDING STAGE.

The Ventnor Urban District Council invite

Tenders for the Repair and

REPLACEMENT of a number of TIE RODS and OTHER IRONWORK to the understructure of the Royal Victoria Pier and Landing Stage, Ventnor

Plans, Sections and Specification may be seen, and full details obtained, at the office of MR. D. V. HOWARD, the Engineer and Surveyor to the Council, Town Hall, Ventnor, I.W.

Tenders, sealed and endorsed, "Pier Repairs," to be delivered to the undersigned, Clerk to the Council, not later than Noon on the 7th day of September, 1921.

The Council do not bind themselves to accept the lowest or any Tender.

(Signed)
R. HUGHES OAKES,
Clerk to the Council.
Town Hall, Ventnor, I.W.
30th July, 1921. R 635

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the

following STORES, namely:

No.		Fee for Specification.
1.	Steel Work for Bridges	£1.
2.	Laminated Springs	£1.
3.	Steel Screw Couplings, &c.	£1.
4.	Crank Axles and Straight Axles ...	10s.

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.

The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Great Indian Peninsula Railway Company.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Steel Work for Bridges," or, as the case may be, not later than Eleven o'clock a.m., on Tuesday, the 23rd August, 1921.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALFOLD,
Company's Offices, Secretary.
43, Copthall Avenue, E.C. 2.
London, 10th August, 1921. R 743

TO FIRMS WANTING CONTRACTS.

Tenders are Invited from

Large and Small firms for the Manufacture in various quantities, on a repetition basis, of the following, either separately or collectively:

(1) BRASS DOUBLE-ACTING, HAND-OPERATED AIR PUMPS, 4 in. bore by 12 in. stroke;
(2) COMBINED DIRECTION CHANGING CONTROL COCK AND SAFETY SWITCH for above (no electrical knowledge required), and
(3) DOUBLE DURALUMIN TANKS in several sizes and with the air exhausted from one chamber.

It may be desirable to allot work to one or to several firms, according to circumstances. Allotment of contracts depends entirely upon terms and the advertiser does not bind himself to accept the lowest or any tender. Complete working drawings, specifications and manufacturing details will be forwarded upon application and payment of the fee of £1 1s., which fee cannot, under any circumstances, be returned.

Applications should be addressed to Mr. H. GEORGE HARLEY, Consulting Engineer, at Grand Avenue, Camberley. R 573

COUNTY BOROUGH OF WALLASEY.

NEW BRIGHTON LANDING STAGE RECONSTRUCTION.

The Corporation of Wallasey invite

Tenders for the Supply and

Delivery of 12 Cast Iron COMPRESSORS, with steel tie rods and plates, for the attachment of Landing Stage Moorings for the above, in accordance with the detailed Plans and Specification prepared by Messrs. WILTON & BELL, Consulting Civil Engineers, Westminster Chambers, 1, Crosshall Street, Liverpool. Plans and Specification may be seen at Messrs. WILTON & BELL'S Offices by appointment, and Contractors desiring to obtain copies of the Plans may do so on payment of £1 1s. Tenders on the Form of Tender provided must be delivered to the undersigned, in a Sealed Envelope, endorsed "Tender for New Brighton Landing Stage Compressors," not later than Noon, Saturday, September 17th, 1921.

GEO. LIVSEY,
Town Clerk.
Town Hall, Wallasey,
2nd August, 1921. R 647

EAST INDIAN RAILWAY.

The East Indian Railway Company is prepared to receive

Tenders for the Supply and

EARLY DELIVERY of:

(1) B.S. Steel Flat-footed RAILS, 100 lbs. per yard, and FISHPLATES (Shallow section).
(2) METALS.
(3) VARNISHES.
(4) SPRING STEEL.
(5) LEATHER CLOTH.
(6) LINOLEUM FLOOR CLOTH,

as per Specifications to be seen at the Company's Offices.

Tenders are to be sent to the undersigned, marked "Tender for Steel Rails, &c.," or as the case may be, not later than Eleven o'clock a.m., on Wednesday, the 24th day of August instant.

The Company reserves to itself the right to divide the order, also to decline any Tender without assigning a reason, and does not bind itself to accept the lowest or any Tender.

For each specification a fee of £1 1s. is charged, which cannot under any circumstances be returned.

By Order,
G. H. LILLIE.
Secretary.
Nicholas Lane, London, E.C. 4.
10th August, 1921. R 744

COUNTY BOROUGH OF WALLASEY.

SEACOMBE FERRY IMPROVEMENTS.

The Corporation of Wallasey invite

Tenders for the carrying out

of that portion of the above work denominated Work "A," which comprises a New FLOATING GOODS LANDING STAGE, approximately 250 ft. in length and 80 ft. in breadth, and Works in connection therewith, in accordance with the detailed Plans and Specification of Messrs. WILTON & BELL, Consulting Civil Engineers, Westminster Chambers, 1, Crosshall Street, Liverpool, the Engineers for the work, at whose offices copies of the Plans and Specification may be seen. Contractors desiring to obtain copies of Plans and Specification may do so on payment of £5 5s. Tenders on the Form of Tender provided must be delivered to the undersigned, in a Sealed Envelope, endorsed "Tender for Seacombe Ferry Improvements, Work 'A,'" not later than 12 noon Saturday, October 15th, 1921.

GEO. LIVSEY,
Town Clerk.
Town Hall, Wallasey,
2nd August, 1921. R 646

BOROUGH OF QUEENBOROUGH.

WATERWORKS.

The Town Council of Queenborough are prepared to receive

Tenders for the Removal of

Existing Pumps in No. 1 Well; the SUPPLY and FIXING complete DEEP WELL PUMPS in duplicate, capacity 12,000 gallons per hour against a head of 250 feet. Also TENDER for the Construction of FERRO-CONCRETE STORAGE RESERVOIR 175,000 gallons capacity with the necessary manhole and ventilator covers, etc., in accordance with plans, specification and Bill of Quantities which can be seen at the Office of Mr. HORATIO SMALL, Borough Surveyor, Queenborough, where forms of Tender can also be obtained.

Copies of the plans, specification, etc., can be obtained on payment of Two Guineas which will be returned on receipt of *bona fide* Tender with plans, specification, etc.

Tenders endorsed "Tender for Pumping Machinery and Reservoir" addressed to the undersigned to be delivered at the Town Clerk's Office, Town Hall, Queenborough, not later than Thursday, the 1st day of September, 1921.

By Order,
R. CECIL HARRIS,
Town Clerk.
Town Hall, Queenborough,
2nd August, 1921. R 719

THE HIGH COMMISSIONER FOR INDIA is prepared to receive

Tenders from such Per-

sons who may be willing to SUPPLY TELEGRAPH CABLE.

The Conditions of Contract may be obtained on application to the Director-General of Stores, India Office, Whitehall, S.W. 1, and Tenders are to be delivered at that Office by Two o'clock p.m., on Tuesday, 30th August, 1921, after which time no Tender will be received.

G. H. COLLIER,
Director-General of Stores. R 705

For Sale.—Sittingbourne

Urban District Council.—TWO TANDEM COMPOUND SURFACE CONDENSING ENGINES, and ONE GALLOWAY BOILER (about 15 ft. by 6 ft.), all as now fixed. Can be seen on application to the Engineer at the Waterworks, Keycol Hill, near Sittingbourne. Tenders to be delivered to G. H. POTTER, Clerk to the Council, Sittingbourne. R 730

APPOINTMENTS OPEN.

DONCASTER EDUCATION COMMITTEE.

Junior Technical School.

METAL WORK TEACHER WANTED at once. Full particulars may be obtained from J. EAGLES, A.R.C.Sc., Principal, Technical College, St. George Gate, Doncaster.

G. R. H. DANBY,
Secretary.
Education Offices,
Doncaster. R 693

THE UNIVERSITY OF LIVERPOOL.

LECTURESHIP IN METALLURGY.

The Council invite

Applications for the Post of

ungraded LECTURER in METALLURGY for Session 1921-1922 at a salary of £300, duties to commence on 1st October, 1921. Applications and three copies of testimonials should be forwarded to the Registrar on or before 26th August.

EDWARD CARNY,
Registrar.
3rd August, 1921. R 681

THE UNIVERSITY OF SHEFFIELD.

FACULTY OF ENGINEERING.

Applications are Invited for

the POST of ASSISTANT LECTURER IN MECHANICAL ENGINEERING.

Salary £400 per annum, including evening work during Winter Session. Candidates holding a University Degree with Honours in Mechanical Science preferred.

Applications, stating particulars of training and experience, accompanied by three testimonials, should be sent not later than August 20th to the undersigned.

W. M. GIBBONS,
Registrar. R 529

THE UNIVERSITY OF MANCHESTER.

DEPARTMENT OF ENGINEERING.

The Council is about to proceed to the

Appointment of an Assistant

LECTURER in ENGINEERING and INSTRUCTOR in DRAWING, who would be expected to enter on his duties on 29th September, 1921.

Salary £300 per annum. Further particulars may be obtained from the INTERNAL REGISTRAR. Applications, giving 3 references, should be sent to the INTERNAL REGISTRAR not later than 26th August. Testimonials (one copy of each, which need not be printed) may be submitted. R 707

UNIVERSITY OF LONDON, UNIVERSITY COLLEGE.

Applications are Invited for

the position of SENIOR ASSISTANT in the Department of Civil and Mechanical Engineering, which is under the direction of Professor E. G. Coker. The work requires training and experience in Engineering Design and Drawing Office practice.

Salary £450 to £600 (pensionable) according to qualifications and experience. Further particulars may be obtained from:

WALTER W. SETON, M.A., D.Litt.,
Secretary,
University College, London,
Gower Street, W.C. 1. R 639

LOUGHBOROUGH COLLEGE.

H. SCHOFIELD, M.B.E., B.Sc., A.R.C.Sc., D.I.C., Principal.

Wanted, Instructor in Oxy-

Acetylene and Electric Welding in the Works Departments of the above College.

It is regarded as essential that candidates shall be fully skilled craftsmen, capable of giving practical demonstrations to students.

As the successful applicant may be required to deliver lectures on these subjects, only those possessing a sound theoretical and general training should apply.

Commencing salary £365 per annum.

Applications, giving full details of age and experience must be submitted to the PRINCIPAL of the College not later than Wednesday, 24th August, 1921. R 738

SALES AND ADVERTISING.

Wanted, Immediately, Chief

ASSISTANT for Sales Promotion Department. Must be able to write advt. copy and form letters and able to prepare booklets, catalogues, etc. Drawing office experience, especially if connected with piping systems (water or gas mains, steam pipes, etc.) an advantage. Excellent opportunities of advancement for right man. Application must be made in writing, giving age, salary required and details of experience. Any reference copies, specimens of work, etc., submitted, will be duly returned after perusal.

VICTORY PIPE JOINT CO., LTD.,
28, Victoria Street,
London, S.W. 1. R 720

London Representative

WANTED by a firm of Constructional Engineers in the North to secure orders for Pit Tubs, Light Railway Stock and Constructional Steelwork. To a suitable man the prospects are very good and a high salary and bonus will be paid. Reply should state in confidence age, experience, references and suggested remuneration.—BOX 286, WILLINGS, 125, Strand, W.C. 2. R 636

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Traveller Wanted, London

District, with thorough knowledge of trade, markets, etc.—State experience, qualifications, remuneration expected, when free to JOHN M. HENDERSON & CO., King's Works, Aberdeen. R 739

Wanted by a Leading

Engineering Firm, specialising in the manufacture of Coal Cutters and Coal Conveyors, a FIRST CLASS MAN to take charge of drawing office. Preference will be given to applicants having experience in these specialities. A progressive man with initiative is wanted, having Mechanical and Electrical knowledge, able to produce designs in line with modern requirements and modern methods of production.

Applicant must state fully age, experience, present position and salary required.—Address, R 705, Offices of ENGINEERING.

Engineer, under 32, un-

married, with civil, mechanical and electrical experience, WANTED for Persia. Initial Salary, 1,000 rupees per month, with benefits of Provident Fund and quarters.—State age, education, experience, war service, to STRICK, SCOTT & CO., Ltd., Winchester House, E.C. 2. R 726

Engineer (Practical) Wanted

to TAKE entire CHARGE of Boilers, Economisers, Quickspeed Engines and Turbo Set, A.C. and D.C. Generators and Motors, Shafting, Gearing, etc., in a large textile works. Should be a fair draughtsman and able to lay off Buildings and Heavy Foundations. Ex-service man preferred.

Apply stating age, experience, and salary expected.—Address, R 667, Offices of ENGINEERING.

Mechanical Engineer (age

about 35) REQUIRED for Copper Mill in South Ireland. Experience in Erecting and Running Internal combustion (Producer Gas and Oil) Engines essential; knowledge of Electricity an advantage. Free furnished bachelor quarters provided.

State salary required and enclose record of past experience with copies only of more important testimonials—originals cannot be returned.

Address, R 696, Offices of ENGINEERING.

Draughtsman Wanted by

MIDLAND ENGINEERING FIRM, having sound experience in design, detailing and quantities covering Conveying, Elevating, Screening, Sorting and Storage Plants, etc. State age, experience, salary required and when at liberty.—Address, R 680, Offices of ENGINEERING.

Wanted Chief Draughtsman,

thoroughly experienced in all classes of Aerial Ropeways, must be good organiser. Good opportunity for fully qualified man. State full details of experience, age, and salary required.—Address, R 716, Offices of ENGINEERING.

Draughtsman Wanted—

Up-to-date in colliery plant, Yorkshire District; only those giving fullest particulars, age and references entertained. No wasters need apply.—Address, R 683, Offices of ENGINEERING.

Draughtsman Required

by the GOVERNMENT of the GOLD COAST for RAILWAY CONSTRUCTION for two tours each of not less than 12 nor more than 18 months' continuous service. Salary £500 a year. Outfit allowance of £60 paid on first appointment. An allowance of £60 a year additional to salary is paid to married officers during the year 1921. Free quarters or a field allowance in lieu at the rate of £7 10s. 0d. a month. First-class passages provided. Liberal leave in England on full salary.—Candidates, not over 45 years of age, who must be good draughtsmen with considerable experience in an engineer's office preferably on Building Construction, should apply at once in writing, giving age and brief details of experience to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting M/Gold Coast 10989. R 737

THE SUDAN GOVERNMENT RAILWAYS AND STEAMERS DEPARTMENT, require the

Service of Three Foreman

FITTERS. Starting salary, £E 300 to £E 324, according to qualifications, plus a temporary war gratuity of £E 120 per annum.

Strict medical examination.

Applicants should be trained in locomotive work and have had subsequent running shed experience, and also some technical qualifications.

Age 25-30 years; preferably single.

The posts are progressive and pensionable after satisfactory probation.

ONE ENGINEERING FOREMAN.—Starting salary, £E 360 per annum, plus a temporary war gratuity of £E 120 per annum.

Applicants should have had special training in machine shop practice and fitting. Experience in smithing and moulding would be considered an added qualification.

Strict medical examination.

Age 28-34. Preferably single.

The post is progressive and pensionable after satisfactory probation.

ONE STEAMER ENGINEER for Nile Shallow Draft Steamers. Salary £E 300 per annum, plus £E 120 war gratuity.

Strict medical examination.

Age 26-33. Preferably single.

Applicants for the post should possess a second-class B.O.T. certificate.

The post is progressive and pensionable after satisfactory probation.

All applications should be addressed to the INSPECTING ENGINEER, Egyptian and Sudan Governments, Queen Anne's Chambers, Broadway, Westminster, S.W. 1, and the envelopes marked "FOREMAN FITTER," "ENGINEERING FOREMAN" or "STEAMER ENGINEER." R 750

THE TECHNICAL EDUCATION OF THE CIVIL ENGINEER.

Most of our colleges appear to have devised their curricula for civil engineers—the term "civil" is used in its popular sense—as if they were really intending to become mechanical engineers with a knowledge of surveying. There is, however, in some respects more affinity between the work of an architect and that of a civil engineer, and the two professions are sometimes combined. The mechanical bias given to students at our colleges is probably due to the fact that most of the heads are mechanical engineers, and that the majority of students intend to follow that branch of the profession. This necessitates a certain amount of grouping of classes for the sake of economy. Nevertheless, if the normal career of a civil engineer be considered, it will be seen that the usual course of study might with advantage be modified, whether the object be to turn out students as efficient junior draughtsmen able to command a living wage on leaving college, or to give them a grounding in the principles of their profession which may be of use to them when they attain to responsible positions later. The consideration of students who are to become research specialists is omitted here, as their number will be small, although their effect on the advancement of the profession may be considerable. The second alternative is the one usually considered as the ultimate object of engineering education, but the first is one which is unfortunately very often present in the minds of those parents who feel the financial strain of the usually long period of education and practical training, during which the young engineer is not supporting himself, and the conflict between the two views bids fair to become keener as competition increases. The decision as to how far one or other must be followed or how far they may be combined, is one which has to be made at the outset, for upon it the entire arrangement of the course of studies depends.

Let us see what will be the normal course of the student of average ability when he enters the works after a college course. If he is a pupil he will have a certain amount of freedom to inspect work, whereas if he obtains a post as paid assistant his opportunities of looking about him will be fewer. On the other hand, it is often found that the responsibility which attaches to a paid post, however subordinate, is a powerful incentive to accurate and patient work, and that in practice the rate of progress of the youth will be nearly the same, whether he is a pupil or paid assistant. He will probably spend a considerable time in tracing drawings, taking off quantities of simple works or details, setting out or surveying on a small scale, or even holding the end of a tape while a senior assistant does the more responsible portion of the work. In none of this does his previous mathematical training count for much, but his regret is probably mitigated for a time by the novelty of his surroundings and his keen desire to learn what he can. After a few months, when he has "found his feet" and knows the routine of the office, he may be entrusted with the outdoor supervision of some small work, subject to the vigilant eye of a senior assistant, or he may be allowed to prepare the draft design of some detail from a rough pencil sketch furnished to him by the chief draughtsman. He will now probably find his carefully calculated dimensions ruthlessly cut about with the curt remark that "this looks too flimsy" or "that looks too heavy," and he will begin to lose faith in the theory that he was taught at college. Here he falls into error, and he will find as he progresses and the jobs of which he has charge become bigger, that this "judgment by eye" is no longer applied with the same confidence to the larger works, and that the sizes have now more often to be arrived at or checked by pure calculation. He may even find that some special problem occurs which cannot be solved at all by the use of the judgment based on experience and that the once despised mathematics must be called in to aid.

During the supervision of work carried out by contract he will have to consult the specification very frequently, and will learn his first lessons in the difficult art of doing his best for his employers while being just and fair to the contractor, or if he is employed by a contractor he will have the other side of the case before his eyes. He may then have designs to check theoretically for stability and strength, and he will learn how a cautious engineer with the full responsibility of the work on his shoulders plays always for a reasonable margin of safety. He will also find himself continually asking the question, "How will this alteration affect the cost?" He will note prices obtained from various completed jobs and so become able to estimate for new work.

Later, the design of more important works will be entrusted to him—where his theoretical knowledge will now be in constant use—and he will write specifications (probably based on previous ones with the necessary modifications). He will prepare schedules of quantities, and if a contractor's engineer will become thoroughly familiar with the cost of works in order to price such schedules when tendering. He will become familiar with various types of machinery, but principally from the point of view of cost and output, in which will be included horse-power and efficiency, and not with regard to its detailed design, the case being analogous to that of a carpenter who can judge a good saw when he sees one, and yet may not know the details of its manufacture. And, finally, he will learn how to carry out administrative duties with accuracy and despatch, delegating routine work and some of the directional work to assistants in proportion to their capacities, so that each shall feel himself justly treated and yet none shall find time hanging on their hands.

If the above account gives a fair idea of the experience which an average student will pass through, what are the subjects which could be studied most profitably with this end in view. It is useless here to speak in generalities, and an endeavour will be made to indicate in detail those subjects which will be of direct benefit, and which at the same time could be comprised within the three sessions of 900 hours each usually allowed:—

(1) Drawing, tracing, inking in, printing up, colouring, and sun printing. Drawing objects such as a small bridge from actual measurement. Neatness essential.

(2) Mathematics, including the calculus up to simple integration and differentiation for maximum and minimum, geometry and trigonometry, mensuration, logarithms and the slide rule. The use of squared paper to be encouraged to express variations, and the mathematics to be looked upon as a tool rather than an intellectual exercise. The binomial theorem, series, permutations and combinations, and much of the trigonometrical work dealing with multiple angles to be omitted.

(3) Mechanics including what is usually called applied mathematics. The fundamental conceptions of mass, velocity, acceleration, force, impulse, energy and work, power, &c., treated in such a way that they are made mentally visible in order to cultivate the "engineering imagination," and not as mere mathematical exercises.

(4) Mechanism, commencing with very simple machine drawing for one term only, and comprising a descriptive and illustrated treatment of the common forms of steam and internal combustion engines, pumps, cranes, concrete mixers, excavators, grabs, navvies, &c. Their names and shapes and principles of construction, not their detail design. Methods of measuring their output by indicating, brakes, &c. Methods of measuring energy consumed. Horse-power.

(5) Electrotechnics, dynamos and motors treated as above, transmission of electricity. Description of the simpler forms of apparatus but not the design.

(6) Hydraulics, including hydrostatics, flow in pipes, hydraulics, etc., but not the theory of turbine or pump design.

(7) Building construction and materials.

(8) Strength of materials, including testing of materials, beams and columns, but not torsion or the theory of thick cylinders, more attention being given to the strength of block structures and reinforced concrete.

(9) Theory of structures, roofs, bridges, arches, &c.

(10) Surveying and setting-out.

(11) Quantities, methods of taking-off and preparing schedules.

(12) Civil engineering routine preparation of estimates, plans, specifications, management of contracts, preliminary work, and construction of works in masonry, concrete, timber and steel, heavier than those usually considered under the heading of building construction. The main principles of the construction of foundations, roads, railways, harbours, docks, piers, jetties, water works. Sewerage works, waterways, and large buildings in bare outline.

(13) Geology (physical) and geological maps.

(14) Physics, including heat, light, sound, electricity and magnetism, but not to a high standard.

The subjects are not arranged either in order of importance or priority in time, but there appears to be no harm in adopting the usual course of requiring civil mechanical and electrical engineers to take the same lectures during their first year at college. It will be seen that this draft curriculum corresponds fairly closely with the requirements of the A.M.I.C.E. examination for those who intend to take up "civil" engineering, with the exception of certain important details which are indicated. The London B.Sc. degree in engineering compels civil engineering students to take the theory of machines also. This is a subject which is of little value to most "civil" engineers. On the other hand, quantities and building construction are not required at all, and, in fact, are subjects almost neglected by most of our colleges. This may be due to the idea that they can best be studied on the works—an idea which does not appear to be shared by architects—or to the dearth of qualified teachers, since these subjects cannot be converted into a branch of applied mathematics.

The exact amount of time to be given to each of the subjects and the method of presentation require more detailed consideration than can be given here, but the requirements of the student during his after career should be constantly borne in mind, and all comparatively useless or unsafe theories, however fascinating, omitted, the limitations in practice of those taught being carefully exposed. This, of course, is best done by teachers who have been "through the mill" themselves.

At the end of a three year's course the student should be a fair draughtsman, able to design simple structures with safety, possess a knowledge of construction sufficient to enable him to read contract drawings intelligently—the detailed design of these can only come by long practice—be able to take off quantities in the usual manner and prepare schedules, understand the main principles of Parliamentary work, preparation and management of contracts, estimating and finance, and, lastly, he should know where to turn when he wishes to make a thorough study of any part of his work such as earth pressure, wind pressure, stresses in statically indeterminate structures, reinforced concrete, &c., his previous mathematical and mechanical groundwork being sufficiently thorough to enable him with care and application to take up these subjects without having to learn their "grammar" so to speak.

The subsequent education of the student will be gained in the works and by private study. In this connection it is sometimes advocated that civil engineering students should enter mechanical works for a year. There is one advantage in this; the student is brought into close contact with the workmen and so obtains a knowledge which may stand him in good stead in after years, when he is engaged in the administrative work which is certain to become part of his lot at some time if he prospers. It is a moot point, however, whether this advantage is worth the time spent on it. As far as knowledge of practical processes goes—with the exception perhaps of steel bridge design—the time would probably be better spent on some constructional work as an assistant timekeeper, and on the whole it appears that in these days of relentless competition the benefit would not be sufficient to compensate for the time so spent.

In the same way the time spent in teaching and learning subjects of very little direct benefit is an undoubted economic loss to the profession and the country, and should be eliminated as far as circumstances render this possible.

THE 72-IN. REFLECTING TELESCOPE FOR THE DOMINION OF CANADA.

(*Continued from page* 209.)

THE telescope tube is made in three parts, consisting of a mirror cell, a centrepiece and a skeleton tube. The mirror cell, which is shown in detail in Fig. 10, annexed, is of cast steel, well annealed, and has radial and concentric ribs, on which are mounted the bottom supports for the mirror. These consist of nine counterbalanced pads, arranged in groups of three, spaced symmetrically, with screw adjustment to permit collimating the mirror in the tube. Around the edge of the cell are 12 edge supports to which weighted counterbalanced levers are attached; these act upon a large ribbed bronze ring which encircles the mirror. This system forms the edge support for the mirror, and takes the load when the mirror is in a vertical position. To avoid any possible shifting of the mirror and to maintain the collimation of the optical system, two solid and two spring blocks are put in the side of the cell to bear against the circumference of the mirror. The weight of the mirror cell is 6,300 lb.

The centre piece of the tube consists of a heavily ribbed cylindrical steel casting. It also is thoroughly annealed. The centrepiece is 7 ft. 4 in. outside diameter, 6 ft. 1½ in. high, and weighs seven tons. At its lower end it has a 6-in. flange to which the mirror cell is bolted, while at its upper end is a similar flange to which the skeleton tube is attached. At one side of the centrepiece is a heavy boss where it is attached to the declination axis, as seen on the right-hand side of Fig. 10.

In the lower end of the centrepiece and just above the mirror is a shutter to protect the mirror when not in use. This shutter consists of 12 radial folding sectors, and is opened or closed by turning a hand wheel at the bottom of the mirror cell. The shutter sectors are operated by a system of levers, fastened to a shaft which encircles the inside of the centrepiece and rotates through a series of universal joints. This shaft is operated by a set of spiral gears from the hand wheel at the lower end of the mirror cell. When the shutter is open the sectors lie against the interior wall of the centrepiece, and thus do not interfere with the cone of rays; when closed the sectors overlap so as to form a dust and moisture-proof cover for the mirror. The whole of the shutter arrangement is clearly shown in Fig. 10, while the photographs reproduced in Figs. 11 and 12 show the shutter with the sectors closed and open respectively. An external view of the lower end of the telescope tube is shown in Fig. 16, page 242.

The tube proper, or skeleton tube, is of structural steel. It is an octagonal prism, 7 ft. 4 in. outside diameter and 23 ft. 4 in. long, fitted with a circular channel at top and bottom. The general design is well shown in Fig. 8 published on page 222 *ante*. The main ribs are 3-in. I-beams. The intermediate sections are all octagonal. The tube is well braced with diagonal tie rods which are drawn up to a tension of about 2,000 lb. per square inch. This construction makes the tube rigid and light, its weight being 3,740 lb. With the Cassegrain mirror attachment, weighing 400 lb., at the outer end, the tube deflects only slightly when turned horizontally. Considering the lightness of the tube, its length and the position of the attached load, the slight deflection is truly remarkable; undoubtedly it is the strongest and lightest tube ever built for a telescope. At the top of the tube a circular plate with bevelled edges is riveted in place. This plate serves to hold the various attachments, such as guiding eyepieces, guide handles, spectroscope and visual eyepieces. The length of the telescope tube is such that the primary focus of the main mirror is about 6 in. above its upper end. This enables a double plate-holder for taking photographs on the primary focus, to be conveniently arranged as shown in the upper part of Fig. 13, the guiding and viewing eyepiece and the rods for manipulating the plate-holder being supported by a mounting which can be shifted round the steel plate ring already referred to.

A "spider" is attached to the upper end of the

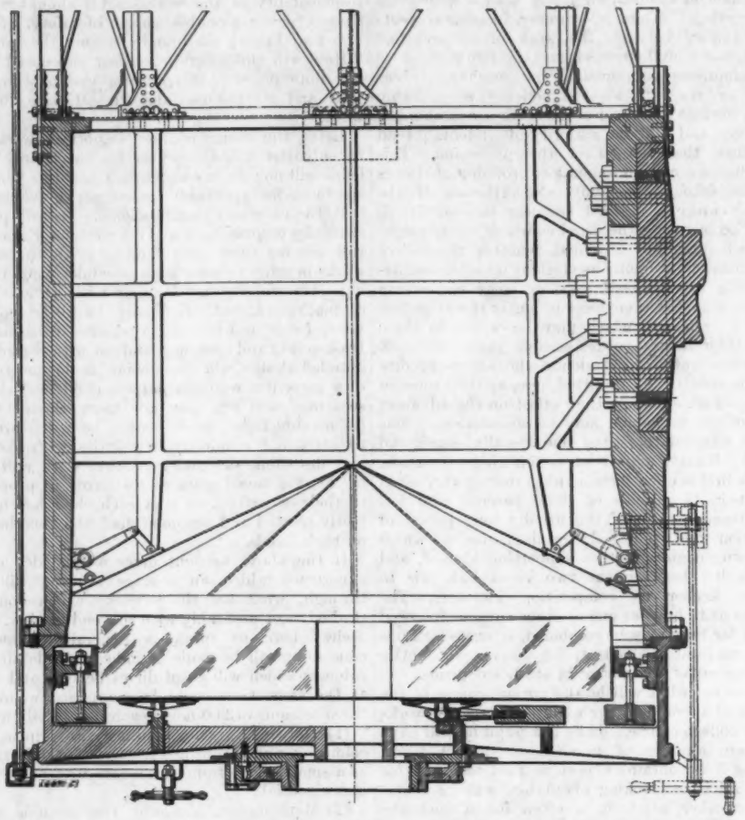


FIG. 10. LOWER END OF TELESCOPE TUBE SHOWING ATTACHMENT TO DECLINATION AXIS AND THE CELL FOR 72-IN. MIRROR.

FIG. 11. SHUTTER FOR PROTECTING 72-IN. MIRROR, SHOWING SEGMENTS CLOSED.

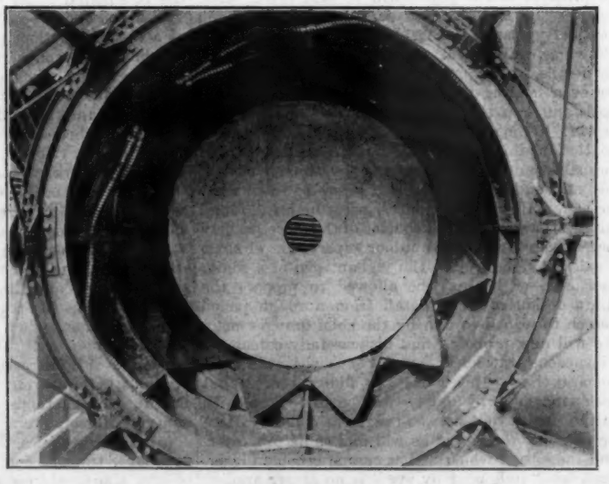


FIG. 12. SHUTTER FOR PROTECTING 72-IN. MIRROR, SHOWING SEGMENTS OPEN.

tube. This supports the plate holder in the prime focus, or it can also hold the Cassegrain or Newtonian mirrors. It is attached by four thin perforated webs, placed edgewise. This arrangement is shown in detail in Fig. 13, which also illustrates the mounting for the Cassegrain mirror. The Cassegrain mirror, which is situated about 7 ft. 2 in. below the principle focus, is supported in a cell which can be moved centrally along the tube for focussing, and tilted upon a spherical bearing seat for alignment. The rods for focussing the Cassegrain mirror are brought down the side of the tube through a spiral gear drive to the lower end where the focussing can be done from below the mirror cell by the observer at the spectroscope. The entire Cassegrain cell aligning and focussing sleeves can be removed as a unit by attaching it to a small chain hoist, loosening the bolts holding the cell to the spider and sliding the whole along a track fastened to the observing platform. This makes a maximum lift of 182 lb., compared with 1,000 lb. to 1,500 lb. lift if the removable cell construction had been used. This feature is a great advance over that adopted in previous instruments, as it enables the telescope to be changed to any form quickly and safely. Whereas it formerly took hours to change from Cassegrain to prime focus observation, the change is now easily and comfortably accomplished in from 10 minutes to 15 minutes. The photograph reproduced in Fig. 14, annexed, shows the Cassegrain mirror and mounting slung ready for being lowered into its place, while Fig. 15 shows it in position.

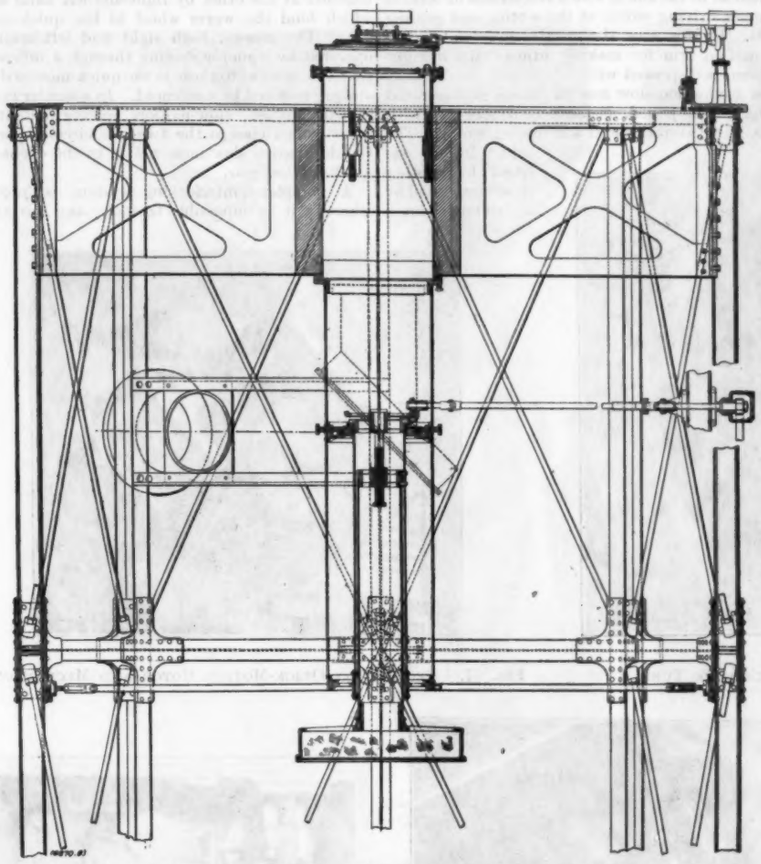


FIG. 13. UPPER END OF TELESCOPE TUBE, SHOWING CASSEGRAIN MIRROR IN PLACE AND APPLIANCES FOR OBSERVATIONS IN THE PRIMARY FOCUS.

The diagonal Newtonian mirror, which has a clear diameter of 19 in., is held in a cell which can be rotated, so that the image can be reflected to any side of the tube. This mirror, which is placed about 4 ft. below the principal focus, can be removed with the same case as the Cassegrain mirror and is bolted directly to the spider in the same manner as the Cassegrain. At the side of the tube there is an adaptor for attaching the plate holder in Newtonian focus, and this can be shifted to either of two positions on the side of the tube. The position occupied by the Newtonian mirror when in place, is shown in dotted lines in Fig. 13.

To facilitate the movement of this great instrument—for its moving parts weigh 43 tons—electric drives are provided. These are called quick motions, and rotate the instrument about either axis at the rate of 45 deg. per minute, or one revolution in 8 minutes. The quick motion about the polar axis, called quick motion in right ascension, is effected by means of the quick motion motor driving by worm reduction to a differential gear-box. If the motor is idle the differential housing is free to rotate when the telescope is moved by the driving clock. To drive the telescope in quick motion it is necessary to start the motor and clamp this housing to prevent it from rotating, the motor driving through the worm reduction and through the differential gears to a pair of bevel gears transmits the power to the pinion meshing into the large quick-motion gear, which is fast to the polar axis. These gears, with the exception of the final gear and pinion, are all run in oil and dust-proof casings located in the south pier head. In a similar manner the declination quick-motion motor, which is illustrated in Fig. 17, page 242, drives through double worm reduction to a differential gear and then through a pinion to the large declination gear which is located in the declination housing and is fixed to the end of the declination axis. This gear is shown in Fig. 7, published on page 209 of our last issue, while a view prepared from a photograph taken with the cover of the declination housing removed is given in Fig. 18, page 242, this view showing the declination clamp and gearing.

A circular clamp is provided for the right ascension quick-motion differential; this is actuated by a hand wheel operating a screw tightening the circular

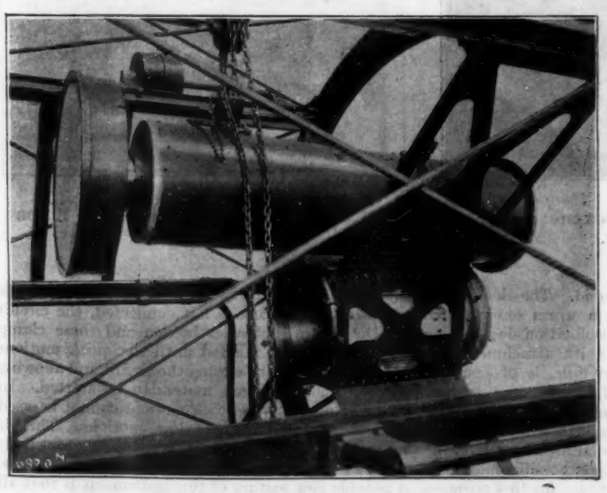


FIG. 14. CASSEGRAIN MIRROR AND MOUNTING SLUNG READY FOR BEING PUT INTO POSITION OR FOR REMOVAL.

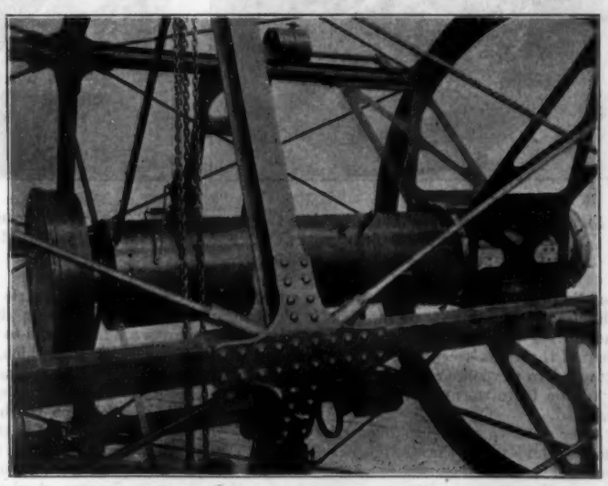


FIG. 15. CASSEGRAIN MIRROR AND MOUNTING FIXED IN POSITION.

clamp. This clamping can be accomplished from either side of the south pier head, for the hand wheel is directly adjacent to the operation switchboards for all motors. The declination quick-motion clamp, being high in the air on the declination housing, is clamped by an electric solenoid drawing down a long lever which operates a cam to press the clamp rings together. When the motor of the right ascension quick motion is running idle it consumes 2½ amperes at 220 volts, and when driving the telescope in right ascension it consumes 3 amperes. It takes only ½ ampere at 220 volts to move the instrument in right ascension, notwithstanding that the total moving weights are 43 tons, while ½ ampere suffices to move it in declination the moving weights in this case being 17 tons. A view of the right ascension clamp motor, which is attached to the large quick-action gear and clamps it to the large worm wheel, is given in Fig. 19, annexed.

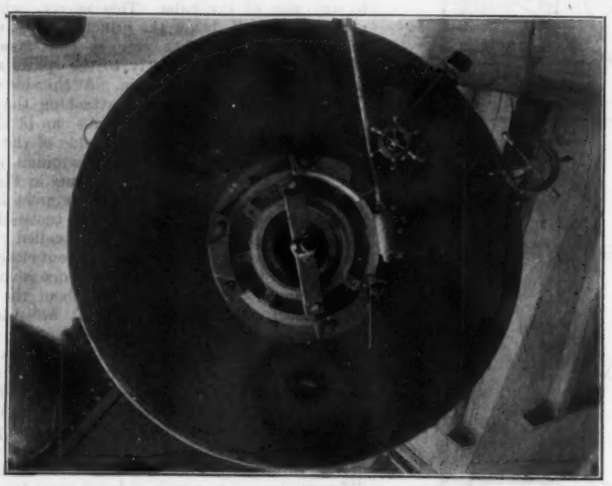


Fig. 16. View of Lower End of Telescope Tube.

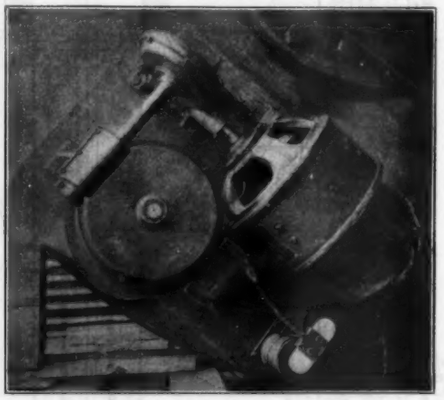


Fig. 17. Declination Quick-Motion Motor and Mechanism.

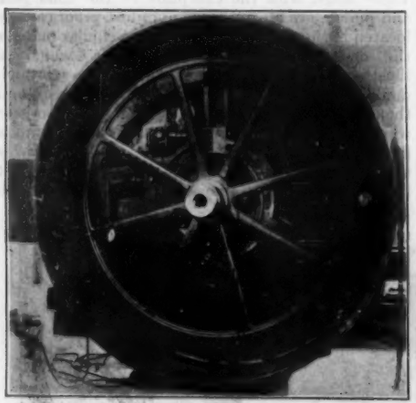


Fig. 18. Declination Housing with Cover Removed, showing Declination Clamp and Gearing.

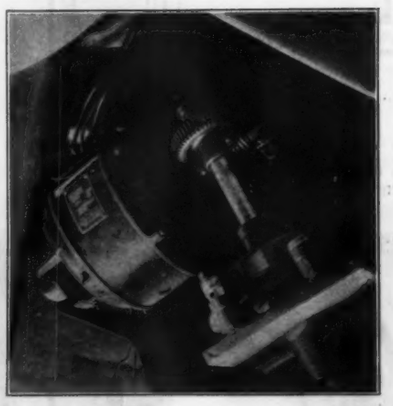


Fig. 19. Right Ascension Clamp Motor.

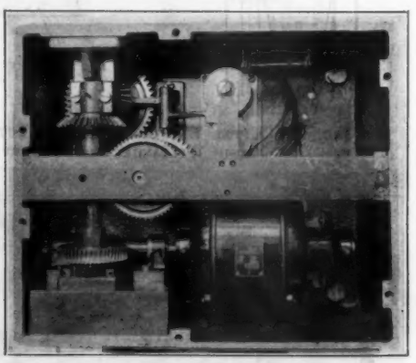


Fig. 20. Declination Slow-Motion Motor and Mechanism.

After the telescope is moved approximately to the position wanted, the star image is brought to the centre of the field of the finder by the use of a slower drive, called the fine setting motion or slow motion. Whenever any local disturbance of the atmosphere causes a change of refraction, the image of the star shifts away slightly from the cross hairs of the guiding telescope and must be brought back into position by a still finer motion, called the guiding slow motion. The setting slow motions in right ascension and declination move the telescope at the rate of 10 minutes of arc in 1 minute of time, or 1 revolution in 36 hours. The guiding slow motions move it at the rate of 30 seconds of arc in 1 minute of time, or 1 revolution in 720 hours or 30 days of time. This rate of movement shifts the star image ⅛ in. per minute across the slit of the spectrograph at the Cassegrain focus. The slow motion in right ascension consists of a five-speed differential in the clock, which accelerates or retards the main driving worm at the setting and guiding speeds. In this way the cumbersome and heavy slow-motion arm for making adjustments in right ascension is dispensed with.

The declination slow motion, which is illustrated in Fig. 20, subjoined, consists of a gear-box with 20 to 1 speed ratios and a reversing motor. The shift from one speed to another is accomplished by a sliding clutch actuated by an electric solenoid. The declination slow motion gearing drives a worm screw which moves a nut fastened to the declination slow-motion arm. This arm, which, with its attachments, is shown in Fig. 7, on page 209 *ante*, is of cast-iron trussed construction, about 7 ft. long, and is very rigid; it clamps to the declination quick-motion gear which is keyed to the declination axis.

As the clock drive to the polar axis must be of the highest precision and smoothest possible motion, a worm and worm wheel was chosen for this purpose. The worm wheel, the position of which will be seen in Figs. 21 and 22, on page 243, runs free on the polar axis and is always connected to the clock through the worm gear. To cause the clock to drive the telescope it is necessary to clamp the worm wheel to the polar axis. This is accomplished by the right ascension slow-motion clamp gearing. This gearing is mounted on the large quick-motion gear, which is keyed to the polar axis. The worm wheel is provided with a hub on its lower side in which a taper groove, 1½ in. wide, 60 deg. angle and 32 in. diameter, is turned. On the quick-motion gear are fastened pivoted bronze shoes which bear in this groove. Semicircular arms carry these shoes; the arms are hinged at one end and drawn together at the other by right-and-left hand screws which bind the worm wheel to the quick-motion gear. The screws, both right and left-hand, are operated by a motor driving through a differential gear-box, similar to those in the quick-motion drives, and are clamped by a solenoid. In a similar manner the declination slow-motion gearing actuates a screw which clamps the two semicircular parts of the declination slow-motion arm to the declination quick-motion gear.

A complete interlocking system is provided whereby it is impossible to make any mistake in the different speed changes. For instance, if the quick-motion gearing is left connected, the circuit for the clamp motors is broken and these clamp motors cannot be started until the quick motions are thrown out, thus closing the circuit and allowing the slow-motion clamp motors to be started. In a similar manner the quick motions cannot be used without unclamping the slow motions. This is accomplished by circuit breakers at the various limit motions on the quick and slow-motion clamps. A notable new feature of this instrument is that all quick and slow-motion gearing and clamping mechanisms are encased in dust and oil-proof housings filled with a thin grease. This feature marks a great advance over previous designs with a multiplicity of oil holes and oil cups and exposed gears which must be frequently gone over.

The driving clock which rotates the telescope at the sidereal rate, i.e., one revolution in 24 sidereal hours, is substantially the same as the driving

clocks provided for the Lick and Yerkes telescopes.* The principal changes are in the addition of electric winding, the slow-motion mechanisms on the principal driving shaft and in making the connections between clock and driving worm wholly by enclosed in a dust-proof case and attached to the main pier, as shown in Fig. 22. It is set in the correct position by adjusting screws. The drum and clock reduction gears occupy the upper half of clock housing, while the conical pendulum is in the as follows: When the clock runs, the differential cases rotate as a unit, and the worm rotates at the sidereal rate. If the left-hand differential case is stopped, the driving worm is accelerated in the ratio of 1 revolution in 30 revolutions of the worm.

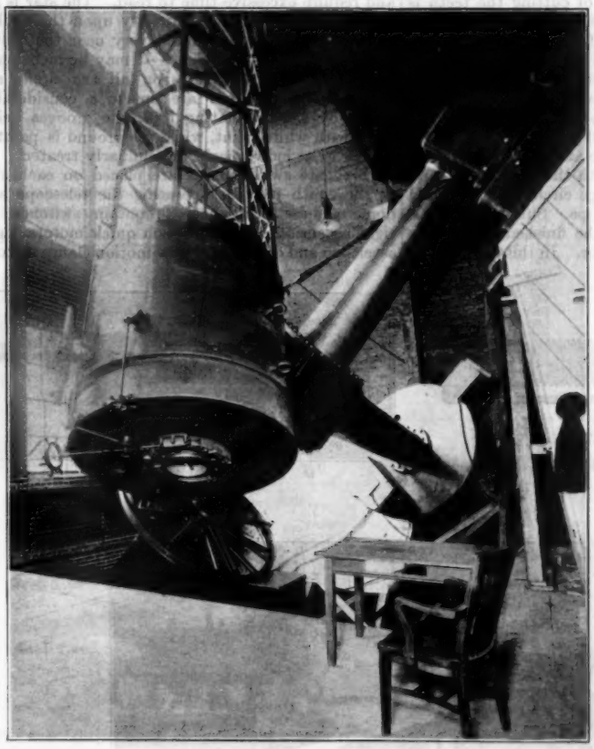


FIG. 21. VIEW, LOOKING NORTH-WEST, SHOWING LOWER END OF TELESCOPE AND DRIVING GEAR.

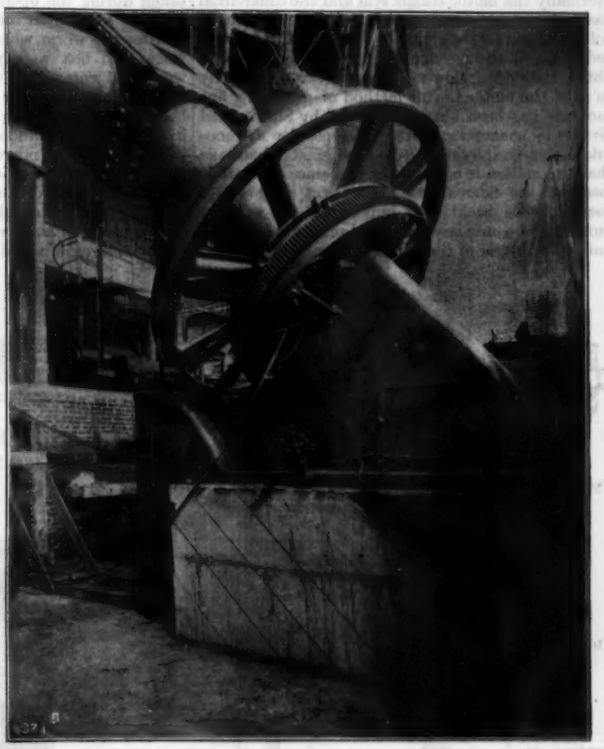


FIG. 22. VIEW LOOKING NORTH-EAST, SHOWING SOUTH PIER AND POSITION OF CLOCK AND DRIVING GEAR.

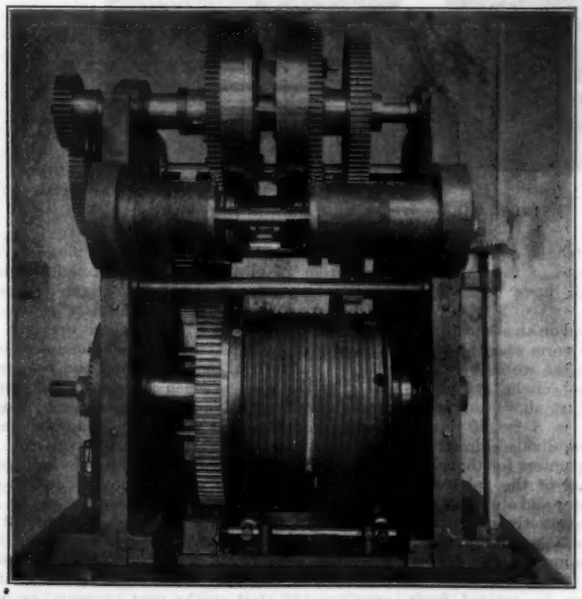


FIG. 23. VIEW OF UPPER PORTION OF CLOCK LOOKING SOUTH.

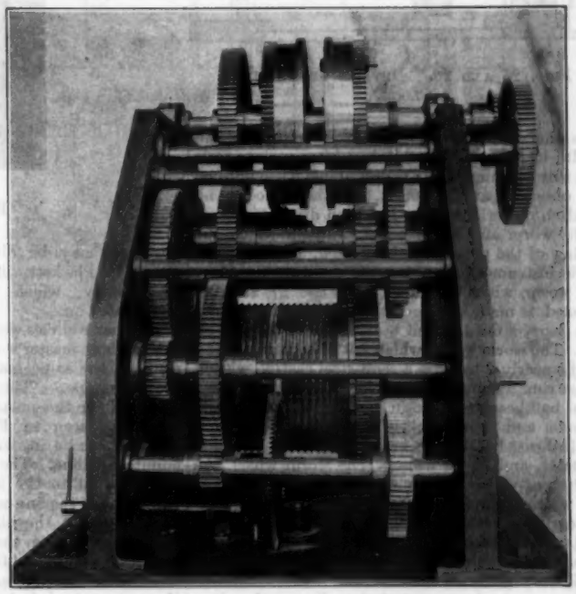


FIG. 24. VIEW OF UPPER PORTION OF CLOCK LOOKING NORTH.

spur gears, instead of bevel gears as in all other clocks. The clock is built as a separate unit, lower half. The clock is driven by a series of weights and is automatically wound. Photographs of the clock are reproduced in Figs. 23 and 24, above, while details are shown by Figs. 23 to 25, on page 244.

In the clock, and integral with one of the shafts, is a five-speed planetary differential which operates When this housing is released and the right-hand differential is stopped, the driving worm is retarded in the same ratio as the other accelerated the worm. This gives the guiding slow-motion speeds. To obtain the fine setting slow motions, which are 20 times as fast as the guiding slow motion, the

* A detailed description of the Lick Observatory and equipment was given in ENGINEERING, vol. xlvi, pp. 1, 81, 149, 155, 200, 225 and 396; while the Yerkes telescope was similarly described in vol. lxxvii, pp. 590 and 663.

differential case is rotated 20 times as fast as the clock rotates it; this either retards or accelerates the worm at this rate, depending on which differential case is rotated. This rotation is given by the slow-motion motor driving a worm attached to the clutches which control the differential housings. Normally the motor stands still and the differential cases are stopped for the guiding motion by means of solenoid operated clutches. Because of the worm reduction in the mechanism it is irreversible. To obtain the setting slow motion it is necessary merely to start the motor. This method of obtaining fine motions has been extensively used by Sir Howard Grubb in connection with telescopes for astronomical photography, and it has the great advantage that the motion is continuous, and since the rate is less than the sidereal rate, the worm is never reversed, hence backlash is impossible. In a slow-motion arm commonly employed on telescopes, the nut often travels to the end of its run; this necessi-

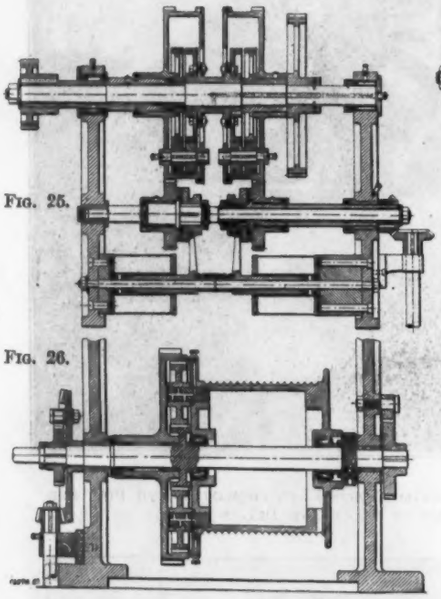


Fig. 25.

Fig. 26.

Figs. 25 and 26. Details of Driving Clock.

tates the reversing of its worm to turn it back, and results in delay and backlash. After various tests with this instrument we are describing, when finished and observing at the 108 ft. equivalent focus, no backlash or periodic error has been discovered.

The worm and worm wheel, through which the driving of the polar axis is effected, are the parts of the instrument requiring the greatest accuracy. The worm, which is shown by Figs. 27 and 28, annexed, is made of forged tool steel finish ground, then lapped until a fine bearing was obtained all over. The worm wheel, which is 9 ft. in diameter and weighs nearly 2 tons, is a semi-steel casting with a bronze rim. It runs free on the polar axis and has two radial ball bearings of 16-in. bore and 22 in. outside diameter and 2½ in. thick. Below these bearings is a ball thrust bearing, 18 in. bore and 23 in. outside diameter, and 2½ in. wide. The worm wheel, the position of which will be seen in Fig. 22, on page 243, weighs complete 3,800 lb. When mounted on its bearings it takes a pull of 2 lb. at 57 in. radius to start it and a pull of ¼ lb. to keep it going.

The method employed in machining this important detail may prove of interest and was as follows: The worm wheel was mounted on its own bearings on a heavy cast-iron pivot and the bearings keyed into place. This pivot was mounted on one end of a long cast-iron bed upon the other end of which was mounted a gear-cutter head. The worm wheel then had a fine trueing cut taken off the bottom and top of rim and the periphery. A 42-in. silver inlaid circle was divided into ½ deg. spaces on the very accurate Warner and Swasey dividing engine. With this circle and the two microscopes for setting, the worm wheel was indexed and the 720 teeth cut in the rim by the gear-cutter head, set for the proper helix angle. Three cuttings were made to avoid any inaccuracies due to heating, springing or changing of the cutter. A view of the worm wheel taken during the operation of cutting the teeth is given in Fig. 29, on the present page.

After the worm wheel had been cut, the driving worm and box were properly adjusted, then the worm and worm wheel were run together with neats-foot oil and rouge for a week. That gave a fine bearing on all the teeth and polished out any minute irregularities. An index circle was then put on the worm shaft and a microscope attached. The worm was indexed ½ revolution with the microscope, and the displacement on the large circle was measured with the micrometer microscope. Subsequent trials by following-on stars with the finished instrument shows no signs of periodic error. In this connection, attention may be directed to the statement of Dr. J. S. Plaskett, the director of the Dominion Observatory, which we shall have occasion to quote later on.

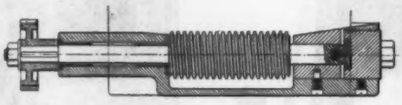


Fig. 27.

Figs. 27 and 28. Driving Worm.

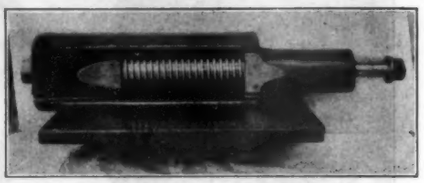


Fig. 28.

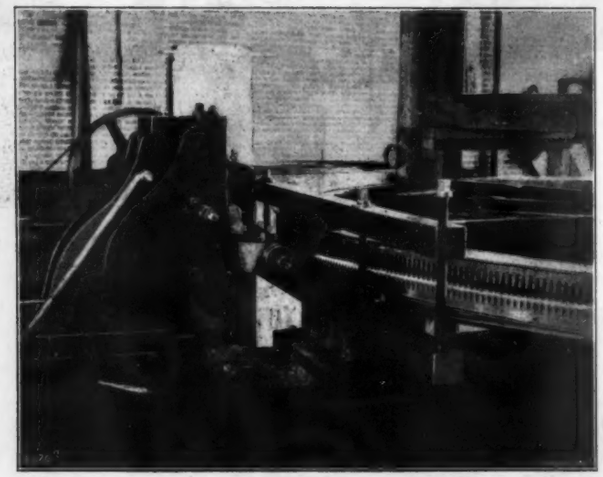


Fig. 29. Cutting the Teeth in the Main Worm-Wheel.

The coarse circles were divided on an accurate gear cutter whose master worm and worm wheel had been made in the same manner as the worm wheel for the telescope. The sidereal circle, which is mounted on the polar axis just above the worm wheel as seen in Fig. 22, is 8 ft. 10 in. in diameter, and 4 in. wide, being divided directly to minutes of time. The index pointers for this circle are attached to the lower end of the polar axis. The width of the line on the index and also the width of the lines of the circle are exactly one-fifth of a minute. Since the spaces are quite large, it is easy to set to one-fifth of a minute. This method is used in the sidereal circle, which is attached to the worm-wheel hub and can be rotated freely on it.

This allows for setting to sidereal time at the beginning of an evening's observing, and permits the instrument to be set directly to the tabulated right ascension of the star which it is desired to observe. The hour circle is divided to 5 minutes of time and is clamped to the polar axis; the index pointers are attached to the south pier head.

The declination circle is 8 ft. in diameter, divided in degrees and a finer reading is provided by an auxiliary dial or drum. This drum is divided to 5-minute intervals and allows easy estimating to single minutes of arc. The instrument is not provided with fine circles, which are cumbersome and require excessive time to read. The star is set to the tabulated position directly upon the circles, and the star is always found very near the centre of the field in the finder. It may be mentioned here that the graduations on all the circles are relatively narrow and are cut to a considerable depth by the graduating tool, the grooves being filled with white paint, while the ground is painted black. The index marks are similarly treated.

Duplicate switchboards are placed on each side of the south pier for operating the telescope and dome. These switchboards contain switches for right ascension and declination quick motors, right ascension and declination slow motion clamp motors, and dome turning and operating motors. The wires from the switchboards go through conduits to the respective motors. The right ascension quick-motion clamp handle is directly above the switchboard. The slow motions are operated by a set of push buttons set in a small aluminium box, about 5 in. by 7 in. by 3 in., which can be carried about by the observer when observing. All motors are equipped with dynamic brake control, making starting, stopping and reversing of motors practically instantaneous.

When one considers the large mass to be moved, and the dimensions of the moving parts, one naturally thinks that such a telescope as we are describing must be a cumbersome instrument to manipulate, yet the change from one star to another, including setting of instrument, changing plate holders and centreing the image in the guiding eyepiece, and starting the next exposure, requires only 3 minutes, and where the stars are close together the change is often done in 2 minutes. This, states Dr. Plaskett, the director of the Dominion Astrophysical Observatory, is a shorter time than is taken to carry out the corresponding operations with the 15-in. refractor at Ottawa.

(To be continued.)

A METHOD OF CALCULATING THE STRENGTH OF SLABS.

By A. INGERSLEV.

(*Concluded from page* 211.)

As an illustration we show in Fig. 8 the breach diagrams for various slabs fixed along one, two and three sides. The B M's over the support are in all cases supposed to be $m_a = 3\,m$; or $k = 3$.

As a further example we will determine the B.Ms. in a square slab partially fixed along one, two, three or four edges.

The B.M. over the support we assume to be only

$$m_a = \frac{1}{3}\,m\,; \quad \left(k = \frac{1}{3}\right).$$

(1) Slab fixed along a_1.

The triangles of fracture have a_2 and a_4 as bases.

$$r_2 = \frac{1}{1+\sqrt{1+\frac{1}{3}}} \times 2r = \cdot 93r$$

$$R_2 = r\,;\ \text{then } h_2 = \cdot 93r\ (\sqrt{3\cdot 865} - \cdot 93) = \cdot 961r$$

$$m = \tfrac{1}{6}\,p\,h_2^2 = \frac{p\,a^2}{26} \quad . \quad . \quad . \quad (18)$$

(2) Slab fixed along a_1 and a_2.

There are triangles of fracture on all four sides, hence we have $h_3 =$

$$\frac{1}{\sqrt{1+\frac{1}{3}}+1} \times 2r = \cdot 93r \text{ and } m = \tfrac{1}{6}\,p\,h_3^2 = \frac{p\,a^2}{26}. \quad (19)$$

(3) Slab fixed along a_1, a_2 and a_3.

The triangles occur on a_2 and a_4.

$$r_4 = \frac{1}{\sqrt{1+\frac{1}{3}}+\sqrt{1+\frac{1}{3}}} \times 2r = \cdot 866r$$

$$R_4 = \frac{1}{1+\sqrt{1+\frac{1}{3}}} \times 2r = \cdot 930r$$

$$h_4 = 0\cdot 866\,(\sqrt{3\cdot 866} - 0\cdot 93) = 0\cdot 895\,r$$

$$m = \tfrac{1}{6}\,p\,h_4^2 = \frac{p\,a^2}{30} \quad . \quad . \quad (2)$$

(4) Slab fixed along $a_1\ a_2\ a_3\ a_4$

$$h_1 = h_2 = h_3 = h_4 = r$$

$$m = \frac{\frac{1}{6}\,p\,r^2}{1+\frac{1}{3}} = \frac{p\,a^2}{32} \quad . \quad . \quad . \quad (21)$$

We now proceed to the consideration of the reactions along the edges supporting the slab.

As the shear is zero along the breach we can say at once that the total reaction on a side is equal to the load on the corresponding breach figure (*i.e.*, triangle or trapezoid).

But for all practical purposes we may also assume, that the load on the beams is distributed as indicated by the figure of the breach, *i.e.*, a triangular or trapezoidal load.

On this assumption we may calculate the B.M. per foot run along the lines M M' and N N' (Fig. 1).

Let the areas of the triangle and trapezoid be F_1 and F_2, and the distance from their centre of gravity to the respective sides ξ_1 and ξ_2, then the bending moment along M M' is :

$$M = m \times l = p\,F_2 \times r - p\,F_2\,(r - \xi_2) = p\,F_2\,\xi_2$$

and along N N' it is :

$$m \times b = p\,F_1\,R - p\,F_1\,(R - \xi_1) = p\,F_1\,\xi_1$$

but

$$F_2\,\xi = S_2 \text{ and } F_1\,\xi_1 = S_1$$

therefore :

$$m_l = m_b = \frac{S_1}{b} = \frac{S_2}{l} = \tfrac{1}{6}\,p\,h_1^2.$$

Finally, we shall show the application of this method of calculation to some other shapes and loadings of slab, that frequently occur.

(1) *A Uniform Load on a Polygonal Slab, the Sides of which all Touch the same Circle.*—(Radius r, diameter d.)

The breach is composed of lines radiating from the centre to the corners of the slab, therefore

$$m = \tfrac{1}{6}\,p\,r^2 = \tfrac{1}{24}\,p\,d^2.$$

This applies to all triangular slabs.

(2) *A Point Load on a Polygonal Slab.*—The sides of the polygon are a_1, a_2, a_3, &c., the distance from the load to the sides h_1, h_2, h_3, &c., and the reactions on the supporting sides A_1, A_2, A_3, &c. We assume the breach to consist of lines from the loaded point to all corners of the slab.

Then :

$$m = \frac{A_1\,h_1}{a_1} = \frac{A_2 h_2}{a_2} + \frac{A_3\,h_3}{a_3} \ldots = \frac{P}{\frac{a_1}{h_1} + \frac{a_2}{h_2} + \ldots} = \frac{P}{\Sigma\,\frac{a}{h}}$$

For a circle with a point load in the centre :

$$\Sigma\,\frac{a}{h} = \frac{1}{h}\,\Sigma\,a = \frac{2\,\pi\,r}{r} = 2\,\pi$$

$$B\,M = m = \frac{P}{2\,\pi}.$$

(3) *Several Point Loads on a Polygon Slab.*—The forces all acting along the circumference of a polygon the sides of which are parallel with the sides of the slab. Also in this case we have :

$$m = \frac{A_1 h_1}{a_1} = \frac{A_2\,h_2}{a_2} \ldots = \frac{P}{\Sigma\,\frac{a}{h}}$$

We can use this formula only when there is no doubt about the breach actually occurring along the lines between the corners of the two polygons.

In the case of point loads one must, of course, bear in mind also the shearing stresses, which probably are the most dangerous.

(4) *A Load uniformly Distributed along one of the Axes of a Rectangular Slab.*—(Fig. 9).

Short axis :

$$m = \frac{p\,(r - \frac{1}{2}\,l)\,R}{2\,r} = \frac{\frac{1}{2}\,p\,h_l^2}{2\,R}\,;$$

$$h_l = R\left(\sqrt{2 + \left(\frac{R}{r}\right)^2} - \frac{R}{r}\right)$$

$$m = \frac{1}{4\,R}\,p\,h_l^2\,;\ 2\,p\,r = P,\ m = \frac{P}{2\,F}\,h^2$$

where F denotes the total area of the slab.

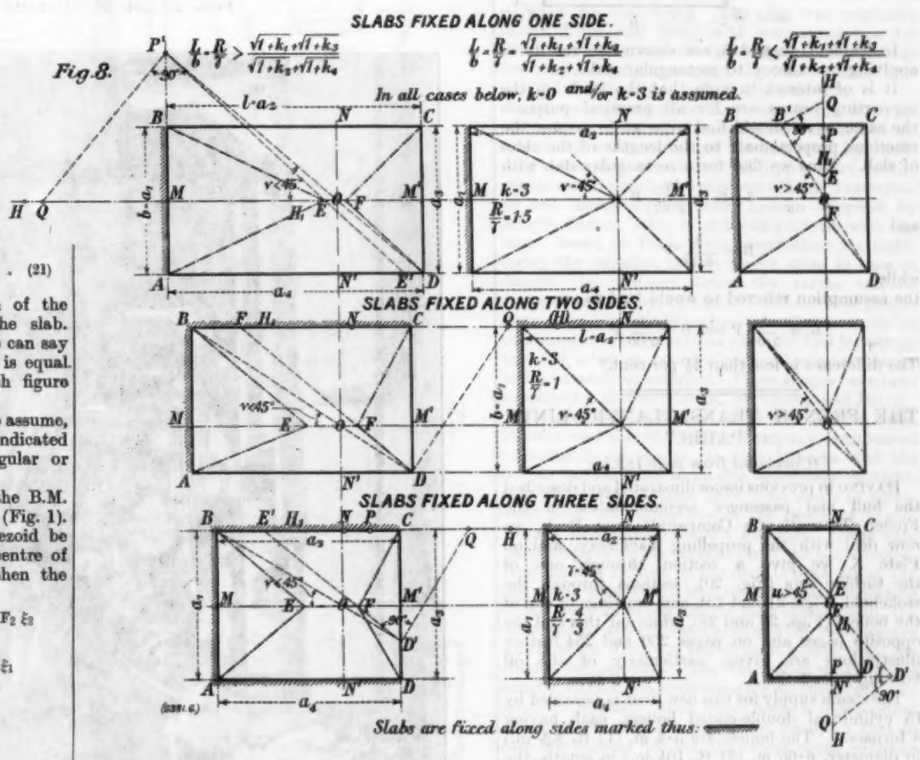
Long axis : $h = r\left(\sqrt{2 + \left(\frac{r}{R}\right)^2} - \frac{r}{R}\right)$

$$m = \frac{P}{2\,F}\,h^2.$$

TABLE I. STRESSES IN RECTANGULAR SLABS, FIXED AT ALL FOUR EDGES.

$\frac{R}{r} = \frac{l}{b} =$	$\frac{h_l}{r} =$	$\alpha =$	$\frac{p\,b^2}{m} =$	$\frac{P}{m} =$	$\frac{P}{B} =$	$\frac{P}{L} =$	$\frac{P\,b}{m_b} =$	$\frac{P\,l}{m} =$
			B.M. in Slab.		Reactions on Supports.		B.M.'s at Support Beams.	
1·0	1·000	45·00	24·00	24·00	4·00	4·00	24·00	24·00
1·1	1·047	46·20	21·95	24·07	4·20	3·82	25·20	22·95
1·2	1·089	47·30	20·25	24·30	4·42	3·66	26·52	22·05
1·3	1·126	48·25	18·95	24·63	4·62	3·53	27·72	21·35
1·4	1·159	49·10	17·85	25·00	4·84	3·42	29·04	20·80
1·5	1·189	49·55	16·95	25·45	5·05	3·32	30·30	20·22
1·6	1·216	50·35	16·25	25·94	5·27	3·22	31·62	19·80
1·7	1·241	51·10	15·60	26·50	5·46	3·16	32·76	19·45
1·8	1·263	51·40	15·05	27·05	5·70	3·08	34·20	19·15
1·9	1·283	52·05	14·60	27·65	5·91	3·02	35·46	18·85
2·0	1·303	52·30	14·14	28·28	6·14	2·97	36·84	18·63
2·5	1·378	54·00	12·62	31·55	7·26	2·76	43·56	17·80
3·0	1·431	55·00	11·70	35·10	8·39	2·62	50·34	17·30
—	1·732	60·00	8·00		$\frac{P\,b\,2}{2\cdot 305}$	2·00	$M_b = \frac{P\,b\,1}{13\cdot 83}$	16·00

Fig. 8.


SLABS FIXED ALONG ONE SIDE.
In all cases below, k-0 and/or k-3 is assumed.
SLABS FIXED ALONG TWO SIDES.
SLABS FIXED ALONG THREE SIDES.
Slabs are fixed along sides marked thus:

While there are in existence a great number of tests referring to slabs supporting a uniform load there are no records representing the cases mentioned above under (2), (3) and (4).

Care must accordingly be exercised in applying these latter formulas until our assumption regarding the breach has also in these cases been verified by experiment. In the meantime they may still be useful in assisting the judgment in these cases, where we have had formerly to be content with very rough approximations.

In the case of a reinforced concrete slab, we must also consider how to reinforce the slab against the bending moments that occur. We note, that at the points E and F the maximum bending moment is the same in three different directions, it must therefore be the same in all directions. If, then, we place the same amount of steel (s) in both directions, then the result will be as if we had that amount in every direction.

To prove this let us consider a section of the slab,

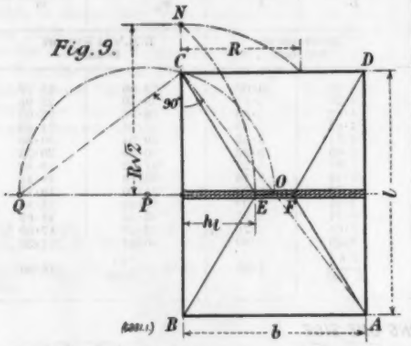
1 ft. long, forming an angle v with the side C of a rectangular slab.

If the reinforcing rods have an area s per foot run in both directions, then the area of bars parallel to l that occur in our section is $s \cos v$ and the area of bars parallel to b that occur is $s \sin v$. If these two sets of bars are subject to the same tension (as they are at the yield-point), then the resultant steel in the section is equal to

$$\sqrt{S^2 \cos^2 v + S^2 \sin^2 v} = S$$

and the direction of this is perpendicular to the section.

Fig. 9.



In Table I, page 245, are shown the results of applying our theory to rectangular slabs.

It is of interest to note that the loads on the supporting beams are for all practical purposes the same as we should find were we to assume the reactions proportionate to the lengths of the sides of slab. Thus we find for a rectangular slab with

$$\frac{l}{b} = 2 \; ; \; L = \frac{1}{2 \cdot 97} \; P$$

and

$$B = \frac{1}{6 \cdot 14} \; P$$

while the assumption referred to would lead to:

$$L = \frac{1}{3 \cdot 00} \; P \text{ and } B = \frac{1}{6 \cdot 00} \; P$$

The difference is less than 2½ per cent.*

THE FRENCH TRANSATLANTIC LINER "PARIS."

(*Concluded from page* 182.)

Having in previous issues illustrated and described the hull and passenger accommodation of the French Transatlantic Company's liner Paris, we now deal with the propelling machinery, and on Plate X we give a section through one of the turbine sets (Fig. 20), sections through the stokehold (Figs. 21 and 22), and drawings of one of the boilers (Figs. 23 and 24), while on this and the opposite pages and on pages 250 and 254 further illustrations are given, particularly of the oil burning installation.

The steam supply for this new liner is provided by 15 cylindrical double-ended boilers, each having 8 furnaces. The boilers are 5·4 m. (17 ft. 8⅜ in.) in diameter, 6·66 m. (21 ft. 10¼ in.) in length, the total heating surface being 9,070 sq. m. (97,600 sq. ft.). The working pressure is 15 kg. (213 lb. per square inch.

The Wallsend-Howden low-pressure system of burning liquid fuel, manufactured by the Wallsend Slipway and Engineering Company, Limited, Wallsend-on-Tyne, was installed in all the 120 furnaces of this ship. The installation gave complete satisfaction both during the trials and also in the first voyage which has just been completed to New York and back, a fitting tribute to the Wallsend Company's long experience in oil burning, which extends over a period of forty years and has been applied to all kinds of vessels, including yachts and giant liners. The standard simple furnace arrangement recommended with the Wallsend-Howden system was not in any way departed from, the only brickwork fitted being that to protect the furnace fronts. The general arrangement of the furnace and oil burner is shown on Figs. 29 to 31, and the burner and its carrier are clearly illustrated in Figs. 32 and 33. The combustion was excellent throughout the voyage, and there was no carbon

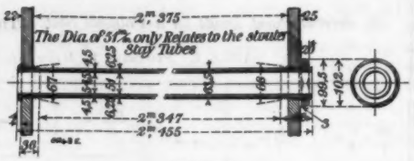


Fig. 26.

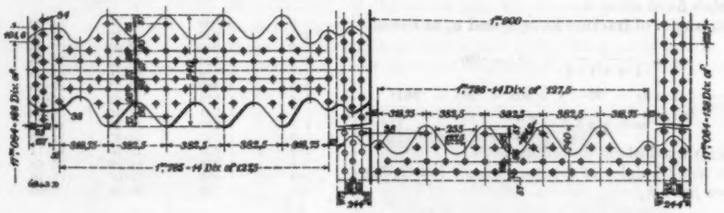


Fig. 25.

Figs. 25 and 26. Details of Boilers.

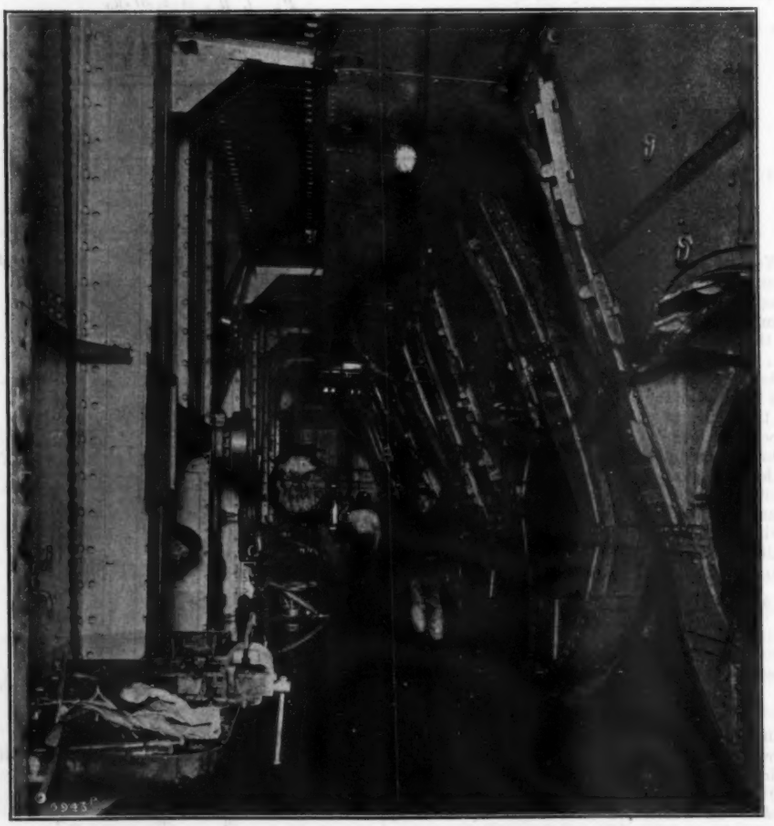


Fig. 27. View in Stokehold, showing Oil-Burning Installation.

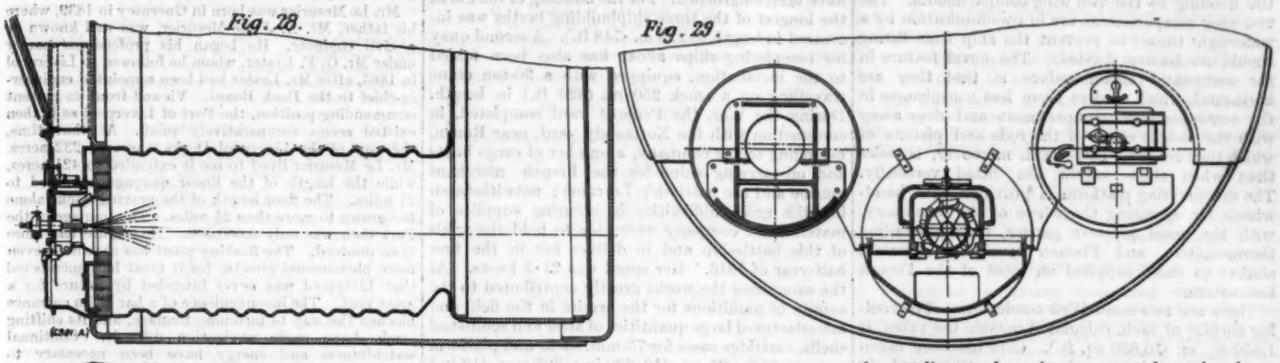
formation in any of the furnaces, the Wallsend-Howden patent air director ensuring so efficient a mixture of oil and air as to obtain complete combustion and maintain perfectly clean furnaces. Ten pumping and heating units were installed, each complete with pump, heater, duplex filter, pressure gauges, relief valves, &c., one unit being fitted at the forward and one at the after end of each boiler room. One unit is capable of dealing with the full load of the boiler room so that the second unit acts as a standby in case the working unit requires cleaning or overhauling. An auxiliary unit is illustrated in Figs. 34 and 35 and by perspective views on page 250. Provision has been made for steaming out the heaters so as to be able to clean them without breaking any joints, a great advantage when using heavy viscous oils which congeal in pipes and tubes if allowed to remain and cool in them. Special oil fuel pumps, arranged for electric or hand drive, are provided for use until steam is raised in a boiler. These pumps are vertical triplex single-acting pumps. The view of one of the stokeholds on this page gives a good idea of the orderliness possible with the oil fuel system, and forms a contrast to a coal burning boiler installation.

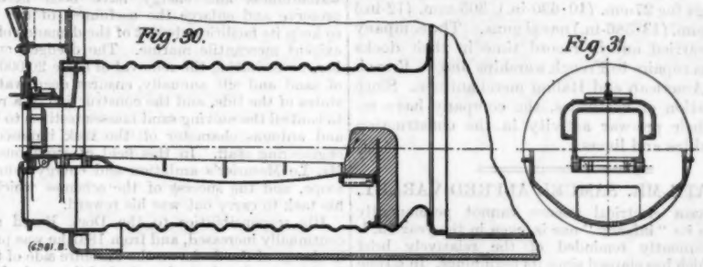
The oil fuel is carried in 20 side tanks and 24 double-bottom tanks, the after tank on each side of the ship acting as an expansion tank, the overflow from all other tanks gravitating to these. There are also two large settling tanks at the forward end of No. 1 boiler room. The fuel capacity of the tanks is 6,160 tons. All tanks are fitted with heating coils so that the most viscous fuel oils can safely be used, however low the sea temperature may be. The side tanks are fitted with high and low suctions arranged in such a manner that all the pumping and heating units can draw direct from any of the side tanks if the oil is of such a quality or in such a condition that there is no need to pass it through

* Erratum.—The last line of the preceding portion of this article on page 211 should read

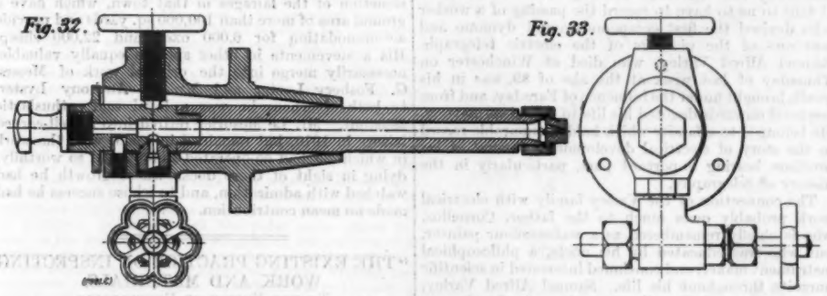
$$p S_n = m (1 + k_n) \cdot a_n$$

OIL-FUEL BURNING SYSTEM IN THE FRENCH LINER "PARIS."





FIGS. 28 TO 31. THE WALLSEND-HOWDEN CONE AIR DISTRIBUTORS.



FIGS. 32 AND 33. WALLSEND-HOWDEN BURNER AND BURNER CARRIER.

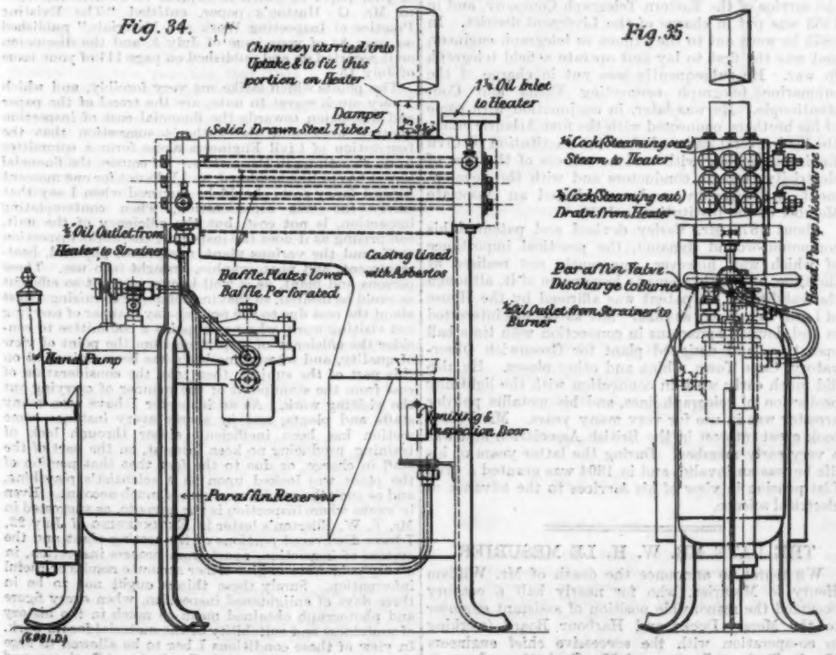


Fig. 34.
Chimney carried into Uptake & to fit this portion on Heater
Damper
Solid Drawn Steel Tubes
1¾" Oil Inlet to Heater
¾ Oil Outlet from Heater to Strainer
Baffle Plates lower Baffle Perforated
Casing lined with Asbestos
Hand Pump
Paraffin Reservoir
Fig. 35.
¾ Cock (Steaming out) Steam to Heater
¾ Cock (Steaming out) Drain from Heater
Paraffin Valve Discharge to Burner
¾ Oil Outlet from Strainer to Burner
Hand Pump Discharge

FIGS. 34 AND 35. WALLSEND-HOWDEN FUEL-OIL HEATER.

the settling tanks. Arrangement has also been made for the transfer of oil from any of the side or double bottom tanks to the settling tanks when required and thence to the pumping and heating units and the burners.

The use of oil fuel has greatly reduced the operating staff from the number which would have been required for coal firing. The ship was originally designed for coal firing with accommodation for 280 officers and men for the boiler rooms, whereas the staff actually operating the boiler rooms now that oil fuel has been adopted is only 124.

Elaborate precautions have been taken to avoid accident or danger; the main valves in the oil system have been arranged for operating hydraulically at a distance—from the upper part of the engine room, close to the engineer officers' quarters—on the Morin—Spillemacker system supplied by Messrs. Cocard, Lille, in order to conform with the latest Board of Trade recommendations for facilitating the isolation of any boiler room in case of danger. In ordinary times the valves can be operated separately, by hand. Pneumercator gauges have been fitted throughout so that records of consumption and quantities of liquid fuel in storage tanks or taken on board when bunkering are easily and accurately ascertained. These gauges have been supplied by Messrs. Kelvin, Bottomley and Baird.

The adoption of oil-fuel firing was decided upon in 1920, and the St. Nazaire Company commenced immediately to render the side bunkers and the double bottom compartments absolutely oil-tight, and all the installations have been made in agreement with the regulations of the Board of Trade, Bureau Veritas and Lloyd's Register. Great care has been given to the ventilation of the boiler rooms. Howden fans located on the deck G draw air at the top of the boiler rooms and, owing to the dimensions of the fresh air inlets and to their distribution, the boiler rooms are well ventilated and the temperature within them is only a few degrees higher than the outside temperature. The five boiler rooms being exactly similar, the conditions for oil fuel firing were most favourable. Each boiler room is independent of the others and is complete in itself, so that in case one became flooded, the others could continue working without difficulty.

The arrangement of the propelling machinery is generally similar to that followed for the first time on the liner France, and is shown in Fig. 16, on Plate VIII, accompanying our issue of July 29, while a section of the intermediate-pressure ahead and low-pressure astern turbines is given in Fig. 20, on Plate X. published with the present issue. In the case of the Paris the four turbines are in three compartments—two wing engine rooms, the port room accommodating high-pressure ahead and astern turbines, and the other—the starboard—having the intermediate pressure ahead and high-pressure astern turbines. The central engine room has two low-pressure units for ahead and astern driving. Automatic valves with Brown's gear are provided so that the high-pressure set or the intermediate-pressure set can be cut out of action; in the latter case the exhaust from the h.p. set passes direct to the low-pressure turbines, and in the former case steam passes direct from the boilers to the intermediate turbine. The low-

pressure turbines allow of boiler steam admission for ahead and astern driving in the event of the flooding of the two wing compartments. The two wing compartments are in communication by a watertight tunnel to prevent the ship from listing should one become flooded. The novel feature in the automatic steam valves is that they are horizontal, which renders them less conspicuous in the central engine compartment and does away with the weight effect of the rods and pistons of which they consist. Inspection, moreover, is easier than when these valves are fitted vertically. The manœuvring platform is provided with hand-wheels for operating the whole of the machinery, with the usual pressure gauges, distance-reading thermometers, and Flaman revolution counters similar to those supplied on most of the French locomotives.

There are two main Weir condensers. The cooling surface of each, calculated outside the tubes, is 1,550 sq. m. (16,680 sq. ft.). Care has been taken to have the tubes as short as possible, and, in agreement with the practice generally followed in the British Navy, the casing is of cast-iron. For each condenser there are two centrifugal circulating pumps, each driven by a high-speed compound engine with forced lubrication, supplied by Messrs. Matthew Paul and Co., Limited. The pump casings are of cast-iron and the discs of brass. Each of the four circulating pumps has a delivery of 4,500 cub. m. (158,900 cub. ft.) per hour at a speed of 450 revolutions per minute. The two air pumps are of the Weir dual type. There are, further, two condensers for the auxiliary hull and engine room machinery, and the exhaust from the evaporators. Each has a cooling surface of about 200 sq. m. (over 2,000 sq. ft.); they are connected to one dual air pump and one circulating pump.

The feed water heaters are of the Contraflo system, constructed by Messrs. Fryer, of Rouen, to the designs of the Contraflo Condenser and Kinetic Air Pump Company; the non-condensed steam flows automatically to the condensers or to the low-pressure turbines. In the central turbine compartment are fitted two sets of three reciprocating feed pumps, four pumps of the six being sufficient to feed the boilers at full power. The pumps and plungers are of brass and the plunger rods of manganese-bronze. There are in the port and starboard engine rooms two sets each of three evaporators; of these latter, two produce 120 tons each per day for boiler feed make up and one 60 tons for the passenger service. The 60-ton evaporators work in conjunction with four fresh water distillers, each of 30 tons capacity. This evaporator plant and the necessary circulating pumps, &c., were supplied by Messrs. Caird and Rayner.

The dynamos, three in number, of 450 kw. capacity, are each driven by Rateau turbines which exhaust into the main low-pressure turbines when the ship is at sea, or to the main or auxiliary condensers when the ship is in port. They are aft of the main engine room in the same compartment as the feed water heaters. Further aft is the compartment containing the Otto Fixary refrigerating machinery.

The main shafts are 385 mm. (15 in.) outside diameter and 210 mm. (8¼ in.) inside diameter; the outside diameter of the propeller shafts is 410 mm. (16¼ in.).

The efficiency of both the turbines and steam generating plant has come up to the expectation of the shipping company and of the builders; the saving in fuel is reported to be equal to that effected with geared turbine propulsion without superheat.

In concluding our description we may note that in order to facilitate the taking down of the main machinery parts, the steam pipe connections have been made on the lower portion of the turbines. The inspection of a turbine can thus be carried out in three or four days.

The Penhoët shipbuilding works, belonging to the Société des Chantier et Ateliers de St. Nazaire, where the Paris was built, it may be added, have been greatly extended since we illustrated and described them in our issue for December 23, 1910 (Engineering, vol. xc, page 847). Two large bays have been added to the engineering shops for the construction of warship turrets, and the plate shops have been lengthened. For the building of the Paris, the longest of the three shipbuilding berths was increased in length to 228 m. (748 ft.). A second quay for completing ships afloat has also been added to the installation, equipped with a 30-ton crane travelling on a track 250 m. (820 ft.) in length. During the War, the Penhoët yard completed, in conjunction with the Normandy yard, near Rouen, belonging to the company, a number of cargo boats and oil-carrying ships for the French merchant marine and the battleship Lorraine; notwithstanding the great difficulties in securing supplies of material the company were able to hold the trials of this battleship and to deliver her in the first half-year of 1916. Her speed was 21·5 knots. At the same time the works greatly contributed to the supply of munitions for the armies in the field and manufactured large quantities of steel and semi-steel shells, cartridge cases for 75-mm. shells and platform mountings for 27-cm. (10·630-in.), 305-mm. (12-in.) and 340 mm. (13·386-in.) naval guns. The company further carried out in record time in their docks numerous repairs to French warships and to French British, American and Italian merchantmen. Since the cessation of hostilities, the company have resumed their pre-war activity in the construction of tank ships and liners.

THE LATE MR. SAMUEL ALFRED VARLEY.

Although electrical science cannot permanently remain in its "infancy" one is, even in the year 1921, not infrequently reminded of the relatively brief period which has elapsed since its beginnings. In a time when there are but few human activities with which electricity and electrical working are not concerned it falls to us to have to record the passing of a worker who devised the first compound-wound dynamo and was one of the pioneers of the electric telegraph. Samuel Alfred Varley, who died at Winchester on Thursday of last week at the age of 89, was in his youth brought under the influence of Faraday, and from boyhood onwards devoted his life to electrical matters. He belonged to a family which holds honourable record in the story of electrical development, several of his brothers bearing important part, particularly in the history of telegraphy.

The connection of the Varley family with electrical work probably owes much to the father, Cornelius, who is chiefly remembered as a water-colour painter, but who was educated by his uncle, a philosophical instrument maker, and continued interested in scientific pursuits throughout his life. Samuel Alfred Varley, the third son of Cornelius, was born in London on March 22, 1832. At twenty years of age he entered the service of the Eastern Telegraph Company, and in 1853 was put in charge of the Liverpool district. In 1855 he went out to the Crimea as telegraph engineer, and was the first to lay and operate a field telegraph in war. He subsequently was put in charge of the submarine telegraph connecting Varna and Constantinople. He was later, in conjunction with some of his brothers, connected with the first Atlantic cable. He read several papers before the Institution of Civil Engineers dealing with various aspects of the flow of electricity through conductors and with the development of telegraphy, and was elected an Associate Member of the Institution in 1858.

About 1875 Mr. Varley devised and patented his compound-wound dynamo, the practical importance of which was, however, apparently not realised at the time, and little seems to have come of it, although the validity of his patent was affirmed by the House of Lords as recently as 1892. Mr. Varley was interested in and devised apparatus in connection with time ball operation, and designed plant for Greenwich Observatory, Cape Town, China and other places. He also did much early work in connection with the lightning protection of telegraph lines, and his metallic powder arrester was in use for very many years. Mr. Varley took great interest in the British Association and was a very early member. During the latter years of his life he was an invalid, and in 1894 was granted a Civil List pension in view of his services to the advance of electrical science.

THE LATE MR. W. H. LE MESURIER.

We regret to announce the death of Mr. William Henry le Mesurier, who for nearly half a century occupied the responsible position of assistant engineer to the Mersey Docks and Harbour Board (working in co-operation with the successive chief engineers Mr. G. Fosbery Lyster and Mr. G. Anthony Lyster), whose experience and energy in extending and improving the facilities of the Mersey Docks have contributed very materially in securing to Liverpool its prominent place in the world's commerce.

Mr. Le Mesurier was born in Guernsey in 1839, where his father, Mr. A. J. Le Mesurier, was well known as a civil engineer. He began his professional career under Mr. G. F. Lyster, whom he followed to Liverpool in 1865, after Mr. Lyster had been appointed engineer-in-chief to the Dock Board. Viewed from its present commanding position, the Port of Liverpool as it then existed seems comparatively small. At that time, the area of the Liverpool Docks was only 232 acres. Mr. Le Mesurier lived to see it extended to 421 acres, while the length of the linear quayage increased to 27 miles. The floor length of the graving docks alone has grown to more than 2½ miles. The tonnage of the Port then was only 6,000,000. This figure has more than doubled. The floating plant has shown an even more phenomenal growth, for it must be remembered that Liverpool was never intended by nature for a great port. The inconvenience of a bar at its entrance blocked the way to incoming tonnage, and its shifting sands have made navigation difficult. Continual watchfulness and energy have been necessary to preserve and enlarge the usefulness of the port and to keep its facilities abreast of the demands of an ever-exigent mercantile marine. The dredged cut at the bar, necessitating the removal of some 20,000,000 tons of sand and silt annually, ensures deep water at all states of the tide, and the construction of a revetment to control the moving sand masses testifies to the novel and arduous character of the task imposed on the engineering staff. In this field of strenuous activity Mr. Le Mesurier's ambition and energy found ample scope, and the success of the schemes which it was his task to carry out was his reward.

His responsibilities to the Dock Board and port continually increased, and from 1881 he was practically in charge of the docks on the Cheshire side of the river. In this capacity, he had control of the works for closing the low water basin at Birkenhead, and of the construction of the lairages in that town, which have a ground area of more than 100,000 sq. yards and provide accommodation for 6,000 oxen and 22,000 sheep. His achievements in other spheres equally valuable, necessarily merge into the original work of Messrs. G. Fosbery Lyster and Mr. G. Anthony Lyster, to both of whom he was a loyal and enthusiastic assistant. Mr. Le Mesurier retired into a well-earned leisure in 1910, but remained in touch with the work in which he had co-operated so long and so worthily, dying in sight of those docks whose growth he had watched with admiration, and to whose success he had made no mean contribution.

"THE EXISTING PRACTICE OF INSPECTING WORK AND MATERIALS."

To the Editor of Engineering.

Sir,—I beg to be allowed a small space in the columns of your paper in which to express views with reference to Mr. G. Hatton's paper, entitled "The Existing Practice of Inspecting Work and Materials," published on page 84 of your issue of July 8, and the discussion on it reported on and published on page 111 of your issue of July 15.

The points which strike me very forcibly, and which I very much regret to note, are the trend of the paper and discussion towards the financial cost of inspection visiting work and the author's suggestion that the Institution of Civil Engineers alone form a committee to do something in the matter. Of course, the financial aspect has to be considered, and I do not for one moment suggest fancy costs should be incurred when I say that surely the first consideration, when contemplating inspection, is not cost, but the efficiency of the unit, comprising as it does the inspector, the works inspection staff, and the various plant, analytical, physical, heat-treatment, and photographic, brought into use. These persons and plant, as is well known, are not so efficient as could be desired, so that in preference to raising a dust about the cost due to the present-day manner of carrying out visiting work, why not appoint a committee to consider the efficiency of inspecting from the point of view of quality, and when some basis has been arrived at on this part of the subject, then take the consideration of cost from the standpoint of the manner of carrying out the visiting work. As an inspector I have seen many staffs and plants, and in nearly every instance some section has been inefficient, either through lack of training, producing no keen interest, on the part of the staff in charge, or due to the fact that that portion of the plant was looked upon as a scientist's plaything, and as such the results were not of much account. Even in works where inspection is the keynote, as suggested in Mr. T. W. Ellerton's letter in Engineering of July 22, I have discovered portions of the testing plant and the system of inspection, apart from process inspection, in a very poor state to give either accurate results or useful information. Surely these things ought not to be in these days of enlightened inspection, when every figure and photograph obtained mean so much in the history of usefulness and suitability of the material for its work. In view of these conditions I beg to be allowed to urge that a Joint Committee of the Institutes of Engineers and Metallurgists take up the subject of efficient inspection,

with the view of bringing about greater unity of method and feeling on this point.

I do not for one moment wish to convey by the above remarks that I hold with the setting up of a general inspection bureau, or that such a bureau would be a success or a useful asset; in fact, I think such a body would tend to reduce the quality of inspection, apart from the fact that it would mean a large amount of machinery for an engineer to set in motion to carry out his particular work. The great asset which we have at the moment, the individual element of the inspector in his work for his *clientele*, would be lost. Also we might have errors made, as the example of a leading inspection body will illustrate, who require that their inspectors, who cover materials, should possess a Board of Trade certificate, necessitating five years' sea experience. In such cases no wonder remarks like Mr. Mannaberg's in reference to an inspector not having seen a steel works, are made. Further, I fail to come to the conclusion that such an organisation would reduce the number of inspectors calling at any one works or batch of works, as I hardly think it would be efficient for one inspector to carry out inspection to every specification in use, or for him to be subjected to the risks, should he inspect the entire output and so be practically resident, of being influenced by the staff or of being imposed upon and treated as a works employee. Trusting in these remarks you will agree with me. I beg to remain,

Yours faithfully,

C. A. HULLS.

Coinfan, Moorland-road, Bargoed, South Wales,
August 2, 1921.

THE 72-IN. REFLECTING TELESCOPE FOR THE DOMINION OF CANADA.

TO THE EDITOR OF ENGINEERING.

SIR,—Your issue of August 5 contains a part description of the very fine 72-in. reflecting telescope erected a few years ago at Victoria, British Columbia, which description we feel sure those of your readers who are acquainted with the exceptionally high-class work required in the construction of astronomical instruments will appreciate.

On page 209, bottom paragraph, column 1, however, it is claimed that "This is the first telescope ever built in which the bearings for alignment are also used as anti-friction bearings." Also that "All previous types of instruments used plain cylindrical bearings for alignment and rollers or mercury troughs to relieve the friction."

We wish to point out that while these statements may be correct as regards bearings for declination axes they are not so as regards polar axle bearings, for it has been our practice for some eighteen years to fit ball bearings, sometimes with and sometimes without supplementary plain bearings, to the polar axes of all telescopes over 6 in. diameter.

For telescopes up to 18 in. diameter (the largest we have made since ball bearings were introduced) we have not considered their use on the declination axis as of sufficient importance to warrant their introduction. It is different, however, with the polar axis. Here not only is the weight to be moved greater, but its frictional resistance has to be overcome by a sensitive driving clock which must run for hours at a time without any apparent change of speed. It is here where the use of ball bearings on telescope mountings shows itself to such advantage. In 1903 we constructed for the late Mr. Franklin-Adams a twin astro-photographic equatorial of a similar type to the one at Victoria. This had ball bearings without any supplementary plain bearings at both ends of the polar axis. A description of it will be found in "Monthly Notices of the Royal Astronomical Society," vol. lxiv, page 624, May, 1904.

As regards self-aligning ball bearings—we have used them on mountings, not only of the English type, where they are distinctly advantageous, but on mountings of the so-called German type, in which the polar axis is generally both shorter and stiffer than in the English type. In all these we have found ordinary ball bearings (and not even self-aligning) answer perfectly.

On account of the great accuracy required in the ball races and the necessary uniformity in the sizes of the balls—both items of much less importance for ordinary engineering purposes—the makers of the bearings in the early days selected them specially for our purpose. Now we are glad to say that so great is the excellence of ball bearings by makers of good repute at the present day that such special selection is quite unnecessary.

Yours faithfully,

(T. COOKE AND SONS, LIMITED),
ALFRED TAYLOR, Managing Director.

Buckingham Works, York, August 10, 1921.

THE EFFECT OF TAPPET CLEARANCE ON TIMING DIAGRAMS.

TO THE EDITOR OF ENGINEERING.

SIR,—In the absence of special compensating devices, the valve timing diagram taken when an engine is cold will not represent the conditions existing when the engine is running if the valve tappet clearances have altered due to differences in expansion.

If the actual clearances be measured whilst the engine is hot after running, then the new opening and closing positions may be calculated and the modified timing diagram obtained.

Any increase in tappet clearance makes the valve open later and close earlier, and if the shape of the cam profile and diameter of tappet roller be known, the corresponding angular displacement of the cam may be found as follows:—

In each case the lift starts at C; if there is zero clearance, and at C^1 if the clearance is x as illustrated.

Let $\phi = C\,O\,C^1$, be the angle turned by the cam before contact occurs at C^1.
R = Radius of cam base circle.
r = Radius of tappet roller.
a = Radius of curvature of cam face.
and x = Clearance between cam base circle and roller.

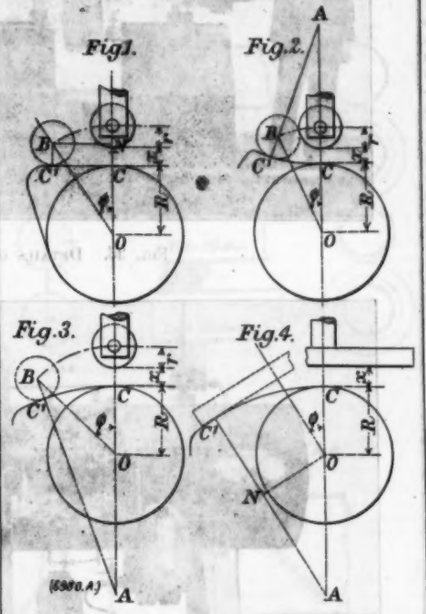
Then for the tangential cam of Fig. 1:

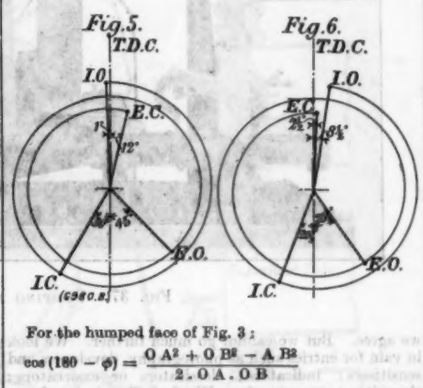
$$\cos\phi = \frac{O\,N}{O\,B} = \frac{R + r}{R + r + x}.$$

For the hollow face of Fig. 2:

$$\cos\phi = \frac{O\,A^2 + O\,B^2 - A\,B^2}{2.O\,A.O\,B}$$

$$= \frac{(a + R)^2 + (R + r + x)^2 - (a - r)^2}{2\,(a + R)\,(R + r + x)}.$$





For the humped face of Fig. 3:

$$\cos(180 - \phi) = \frac{O\,A^2 + O\,B^2 - A\,B^2}{2.O\,A.O\,B}$$

$$= \frac{(a - R)^2 + (R + r + x)^2 - (a + r)^2}{2\,(a - R)\,(R + r + x)}.$$

For the tappet plate of Fig. 4:

$$\cos\phi = \frac{A\,N}{O\,A} = \frac{a - R - x}{a - R}.$$

By division these reduce to:

Case 1— $$\cos\phi = 1 - \frac{x}{(R + r + x)} \quad . \quad . \quad (1)$$

Case 2— $$\cos\phi = 1 - \frac{(a - r)\,x - \frac{1}{2}x^2}{(a + R)\,(R + r + x)} \quad . \quad (2)$$

Case 3— $$\cos\phi = 1 - \frac{(a + r)\,x + \frac{1}{2}x^2}{(a - R)\,(R + r + x)} \quad . \quad (3)$$

Case 4— $$\cos\phi = 1 - \frac{x}{a - R} \quad . \quad . \quad . \quad . \quad (4)$$

To Illustrate the Above.—Consider an engine with tangential cams, base circle 2 in. diameter, tappet rollers 1½ in. diameter, camshaft at half-engine speed, the valve timing diagram taken cold with 0·004 in. roller and cam clearances being:—

I O = 1 deg. E.
I C = 30 deg. L.
E O = 45 deg. E.
E C = 12½ deg. L.
} As in Fig. 5.

Then assuming the running clearances are found to be 0·020 in., we have:

$$R = 1,\ r = 0{\cdot}75,\ \text{and}\ \cos\phi = 1 - \frac{x}{1.75 + x}$$

Putting:

$x = 0{\cdot}004$, $\cos\phi = 0{\cdot}99772 = \cos 3$ deg. 52 min.

$x = 0{\cdot}020$, $\cos\phi = 0{\cdot}98870 = \cos 8$ deg. 37 min.

The difference = 4 deg. 45 min. on the camshaft, showing that each opening and closing position will be altered by 9 deg. 30 min. of crank angle. The modified timing diagram will therefore be:—

I O = 8½ deg. L.
I C = 20½ deg. L.
E O = 35½ deg. E.
E C = 2½ deg. L.
} As in Fig. 6.

Yours faithfully,

C. BROOKS.

INSTITUTE OF MARINE ENGINEERS.—This Institute have now issued particulars of visits to take place and papers to be read as from September 6, also the lists of awards for the session 1921–22. Further particulars may be obtained from the Secretary, The Minories, Tower Hill, London, E.

AERIAL NAVIGATION.—Printed notices, in French, are being issued announcing that the First International Congress of Aerial Navigation is to be held in Paris from November 15 to 26 inclusive. All correspondence should be addressed to the Secrétaire Général du Congrès, International de la Navigation Aérienne, 9, Rue Anatole de la Forge, Paris 17.

BRAZILIAN MINERAL DEPOSITS.—These are at present attracting considerable attention in Europe. Thus Belgian iron works have for some time been investigating the value of certain Brazilian coalfields, at Santa Katharina and Rio Grande do Sul; the results arrived at so far are understood to be very encouraging. The coke derived from the coal in question is stated to be satisfactory, although the yield might be higher. It is reckoned that the revenue from the by-products should make up for this. The coke should make it possible to work up the Esperanza ore within the country. The Burbach-Eich-Dudelange iron works in Luxemburg are said to have secured large iron ore deposits in Brazil, and owing to the low Brazilian exchange the price has been very favourable from the buyers' point of view. A portion of the iron ore produced is intended to be worked up within Brazil.

GERMANY'S LATENT TAX CAPACITY.—Germany should be able to meet the debt service on the bonds to be issued this year under the May agreement, says *The Guarantee Survey*, the monthly publication of the Guarantee Trust Company, New York. She financed her war chiefly through internal loans, and the various governments which have been in office since the revolution have not yet dared to tax the people as heavily as they will have to be taxed. The Wirth Cabinet, however, recently made a beginning in this direction by proposing a vigorous programme of taxation and a plan under which the German Government would appropriate, without compensation, a certain percentage of the shares of every German company, on which it would receive dividends. There is a tremendous latent capacity to raise funds by taxation in Germany. Recent reports speak of good sugar beet, wheat, rye, and oil bean crops this year. New canal construction, railway reconditioning and large manufacturing activity are also reported. The Krupp works at Essen are turning out one locomotive and eight freight cars a day, and are also engaged in producing numerous lines of adding machines, surgical instruments, motion picture projectors, Diesel engines, paper and textile manufacturing machinery, pneumatic tools, &c. What is said of the Krupp works holds in general for other industrial concerns throughout Germany.

ARMSTRONG, WHITWORTH SHIPS.—When Messrs. Armstrong launched the Cunard liner Ausonia from the Armstrong yard in March last, the total shipping production of that firm reached the remarkable figure of 3,000,000 tons. The firm, we understand, has now completed 1,000 ships, of which 800 are passenger and merchant vessels, including cargo boats, oil tankers, ice breakers, train ferries, and other craft for special purposes; the remainder are, of course, various types of warships for the British and foreign navies. The wide range of shipbuilding work carried on by the firm is suggested in a handsome brochure they have recently issued illustrating examples of vessels which have emanated from the Walker, Elswick and Armstrong yards. Among the more notable vessels illustrated are H.M.S.S. Malaya, Furious, Eagle, Courageous, and Dana, and the oil-tank steamers San Fernando and Gluckauf; the latter, it may be mentioned, was launched in 1886, and was the first vessel specially built for transporting oil in bulk across the Atlantic. The brochure, however, includes complete lists of all vessels built by the firm, the merchant ships being arranged under the class to which they belong and the warships according to the yard in which they were built. A plan of the Armstrong Yard, which was opened in 1913, and was fully dealt with in our 109th volume, is also reproduced, together with drawings of a typical cargo steamer, a tank steamer and a vessel for carrying refrigerated cargo. The publication is well printed and illustrated, and is, in every way, a good example of high-class trade literature.

NOTES ON NEW BOOKS.

Recent events in the shipbuilding industry, and in particular the cancellation of contracts for the building of a considerable number of merchant vessels, have compelled the very earnest attention of all interested in the designing and building of ships to the relationship existing between the present cost of construction of new vessels and the probable earning power of such vessels in the near future. The shipowner's point of view is only too plainly indicated by the cancellation of contracts, and is emphasised by the fact that cancellations have in many cases involved the loss of considerable sums of money to the owner. Lower cost of construction is the obvious remedy for this state of affairs, but under existing conditions little can be done by the shipbuilder to ease the situation, and it therefore becomes the more imperative that every effort should be made to ensure that the designs of vessels now being built are such as to secure the maximum of economy in operation costs for the maximum freight-earning capacity. To this end much more careful consideration of the design of cargo-carrying vessels is essential, for it is undoubtedly a fact that in too many cases in the past "rule-of thumb" design for cargo carriers was the rule rather than the exception. That this is so is amply proved by the fact that in practically all the models of proposed cargo vessels tried in the Froude experimental tank it has been found possible to modify the form so as to affect a considerable reduction in horse-power required for driving the vessel at the required speed; in some cases reductions of 25 per cent. in horse-power have been found possible. While it is not possible to try models of each new design in the tank it certainly is possible to make very considerable use of the published results of tank experiments conducted both in this country and America in the design of economical forms of hull and propeller to suit given conditions. As an aid to the rapid application of the data derived from tank experiments we know of no more useful volume than "*Steamship Coefficients, Speeds and Powers*," by Mr. Charles F. A. Fyfe, the second edition of which is now published by Messrs. E. and F. N. Spon, Limited, 57, Haymarket, S.W. 1, price 25s. net. Not only are the results of model experiments given in the most conveniently usable form, but these are simplified and augmented by the actual trial trip results of a very large number of vessels of various types and dimensions. For all who have to deal with speed and power the volume provides a fund of most useful information and, as a convenient summary of recent investigation in all matters relating to hull form, speed and power, we highly recommend the volume.

The very numerous companies and private persons throughout the United Kingdom who from a business point of view are interested in the South African mining and other industries will find much useful information in the "*South African Engineers' Electrical and Allied Trades' Directory*," the 1921–22 edition of which is now available, at the price of 30s. The publishers are *The South African Mining and Engineering Journal*, whose London representatives' address is Byron House, 82–85, Fleet-street, E.C. 4. The book contains an alphabetical list of the principal firms in the Union of South Africa, Rhodesia, Mozambique, &c.; a geographical directory; one of overseas manufacturers stating their representatives in South Africa; a buyers' guide for the help of South African firms; and a directory of mines and metallurgical works in South Africa, and of mine and works' managers.

Trade annuals, we take it, are to serve the interests of two classes of people. There are, on the one side, the manufacturers, anxious to find purchasers for their goods, and on the other side business and private people looking for firms who are able to supply the articles they require. In other publications the author might claim further special consideration; but in trade publications authorship is more a question of compilation, and the publisher will not have to study more than the interests of the two classes we first mentioned, in addition to his own. We are not sure that the unnamed editor of "*The Chemical Trade Year Book and Buyers' Guide*, 1921" (Randon and Morris, 17, Red Lion Passage, High Holborn, W.C. 1. Price 12s. 6d. net) has done this. He does not deny that "there may be cheaper, more bulky and more elaborately-bound volumes professing to catalogue the British chemical trade industry, but on the grounds of the accuracy and comprehensiveness of its contents, and of the clear and straightforward manner in which the information is presented, it is considered that '*The Chemical Trade Year Book and Buyers' Guide*' emerges with credit from the only acid test, that of usefulness and usability." If the straightforward manner refers to the good type and arrangement, we agree. But we cannot go much further. We look in vain for entries such as photography, developers and sensitisers; indicators; dessicators or exsiccators; thermit; manganin, &c. We find Chemicals, photographic, and on the other hand Chemical Plant, both under "C." Colloids are absent; the book knows only two consulting chemists; firms like British Dyes do not appear to exist; the list of Microscopes and Accessories mentions four firms, Photomicrography only one firm, without specifying what they supply, and the only crucibles mentioned are those made of nickel; that there are graphite crucibles is not mentioned, and the name of the one well-known firm in this field is altogether missing. So far the interests of the buyer. We should also consider that advertisers of specialities might expect mention of those specialities; but there are, for instance, no entries devoted to accelerators, or alcohol recovery plants. The 304 pages, we are afraid, leave a good deal to be desired in comprehensiveness.

To the historical rather than to the technical student of the evolution of naval armament the slow and fitful progress made in the design and construction of the ships and guns, and later in the machinery and armour of war vessels, is chiefly interesting. To the technical student the introduction of iron and steel for shipbuilding purposes generally marks the limit of his interest in older theories of design and methods of construction of vessels, while no more than a passing thought is given to propelling machinery of a date previous to the introduction of compound and triple-expansion reciprocating engines, or anything earlier than breech-loading rifled ordnance. In "*The Evolution of Naval Armament*," just published by Messrs. Constable and Co., Limited (price 18s. net), Commander F. L. Robertson, R.N., seeks to trace in popular language the development of the war vessel of 1880 from the earliest types of rowing and sailing vessels. The successive developments of ships, guns and machinery, together with the modifications rendered necessary by progress in any one branch of the warship building industry, are touched upon, while quotations from, and references to, contemporary writers and historians are numerous. The author has had access to, and has freely drawn upon, the early literature bearing upon his subject, and his historical notes on the various stages of development in each branch of his subject, which must have involved very considerable time and labour in research work, are of considerable interest. As has been said, however, it is to the historical student that the volume will appeal as the date, about 1880, to which the author traces the evolution of naval armaments is that at which the modern technical student commences his study of the subject.

OIL FUEL BURNING SYSTEM IN Q-S.S. "PARIS."

(*For Description, see Page* 246.)

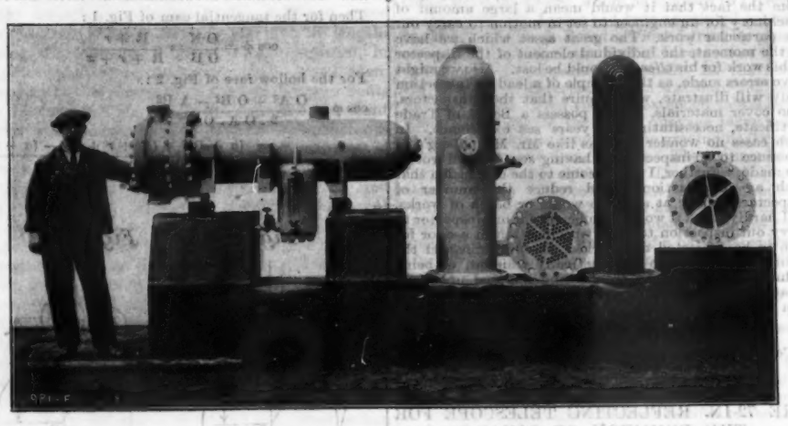


Fig. 36. Details of Oil Fuel Heater.

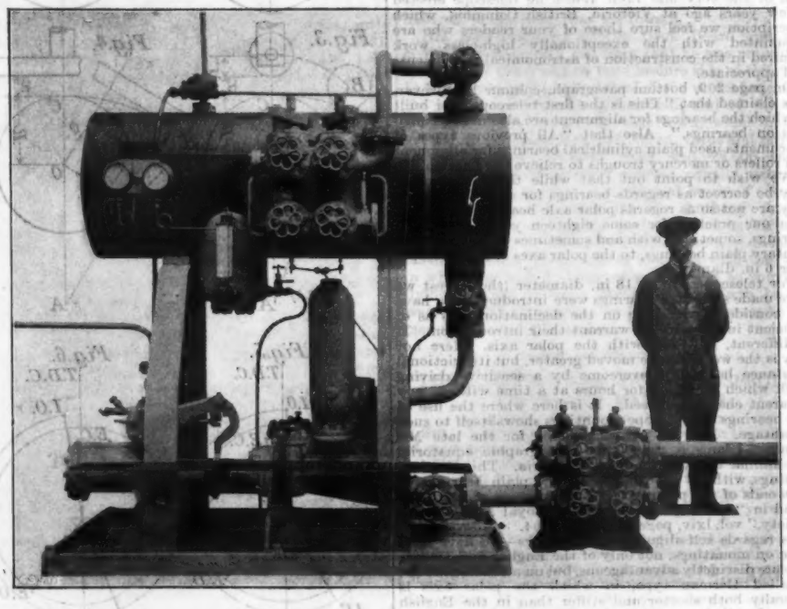


Fig. 37. Pumping and Heating Plant.

REPAIRING CRACKS IN THE COPPER TUBE-PLATES OF LOCOMOTIVE BOILERS.

By A. WRENCH.

THE fire-box tube plates of locomotive boilers sometimes develop cracks between the tubes, and the question of repairing these cracks is a matter of interest. Frequently the work of repairing tube-plates falls to the locomotive running department staff, as at the time the cracks develop, the locomotive may not have run the necessary miles to warrant a shopping for general repairs. Often it is found advisable when a locomotive is sent into the shops, to repair a cracked tube-plate rather than renew it.

Fig.1 BUSH AS RECEIVED FROM FOUNDRY.

Fig.2. BUSH DRIVER.

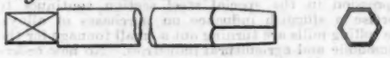


Fig.3. TRIAL PLUG & SPINDLE.

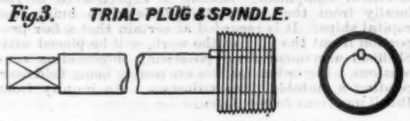
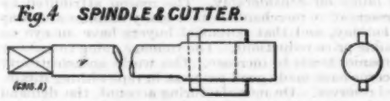


Fig.4 SPINDLE & CUTTER.



The method of repair depends upon whether or not the boiler is empty of tubes. If only a few tubes in the vicinity of the cracks are removed a good repair can be made by screwing the tube holes which have their bridges cracked and inserting tapered brass plugs. Heads are formed on the plugs which meet one another and entirely cover the cracks. The centres of the plugs are then drilled to receive the tubes, the tubes in this case being smaller than the original, to allow of a substantial thickness of metal in the bush. This method makes a fairly good repair, as the tubes have an unbroken contact surface and the cracks are covered and protected by the heads of the plugs.

Another method often employed is to insert plugs as in the previous case, and then bore a tube hole into every alternate plug, leaving the remainder solid, and plugging up the corresponding holes in the smoke-box tube-plate. The tube-plate is thereby strengthened in the parts which are cracked, but the heating surface is reduced and additional stress thrown on stays which may be in the vicinity.

If the boiler is empty of tubes, a standard flanged bush can be used which has a head or flange formed before insertion. This avoids the danger of disturbing the cracks by hammering to form a head. These bushes are received from the brass foundry as shown in Fig. 1, and have an hexagon hole in the centre to enable them to be inserted with the driver shown in Fig. 2. The tube holes, after having been made round with a rose bit, are threaded with a suitable tap, the first, third, fifth, &c., from the fire-box side, and the second, fourth, sixth, &c., from the boiler side. The holes are screwed to the size of the trial plug shown in Fig. 3. The tube-plate is then faced and grooved to receive the flange and tongue of the bush. The bushes are inserted from each side of the tube-plate, their flanges covering the cracked tube-plate bridges on both sides. The tube holes are then bored for the tubes, first by a drill and afterwards by a cutter shown in Fig. 4. This method of bushing makes a good repair which, if properly executed, will not give trouble from leaking. The writer has known locomotives with boilers so repaired to run 40,000 miles without giving trouble from leakage.

Fig. 5 shows cracks in a tube-plate before repair, while Fig. 6 shows an elevation and sectional view of a portion of a tube-plate repaired by these flanged bushes.

Repairing a cracked tube-plate by a patch is not to be recommended, as the width of the tube hole bridges only allows of small rivets or studs being used, and these are too widely spaced apart. The above remarks only refers to cracks between small tube holes.

When the superheater was adopted for locomotive purposes the large tube holes for the smoke tubes carrying the superheat elements greatly reduced the net section of plate across the tube plate, and the compression per square inch on the material was thus increased. As a result cracks developed in the tube-plate bridges. Where direct crown-plate staying was adopted the tube plate was not in compression, but the cracking of tube-plate bridges was not eliminated. The heavy expanding required to make these tubes tight and also the re-expanding during the period of service, which greatly enlarges the tube holes and reduces the sectional area of metal in the bridges accounts for most of the cracks which are found in fire-box tube plates. The size of the superheat tubes is usually 4 in. at the fire-box end. After these have been expanded several times they reach a much bigger size and become deformed, which necessitates them being made round with suitable rose bits. Usually when the tube holes are large one can expect cracks in the rows close to the sides of the plate, as these tubes give most trouble from leakage.

Fig.5. VIEW OF CRACKS IN TUBEPLATE BEFORE REPAIR.

Fig.6. TUBEPLATE REPAIRED BY FLANGED BUSHES.

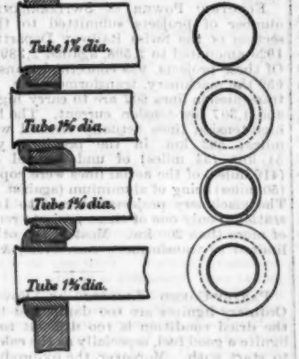
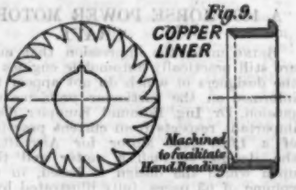


Fig.7. SUPERHEAT TUBEHOLE ROSEBIT & SPINDLE.

Fig.8

Fig.9. COPPER LINER



When a tube plate is found to be cracked, the repair depends on the condition of the rest of the fire-box and locomotive generally. If it is decided not to renew the defective plate, the tubes in the neighbourhood of the cracks are removed and the full extent of the cracks observed. When it is found that the cracks do not pass through the full thickness of the plate, the hole may be trued with a rose-bit, a liner fitted, and the tube replaced. This reduces the tube hole to its original size, and the tube-plate bridges are strengthened by the beaded liner. The crack is caulked close before the liner is inserted. This repair may last some time, until the crack extends through the plate, when it will be necessary to make a further repair.

This can be done by peg-studding and linering, the method adopted being as follows: The tube holes are made round with rose bits, after which a hole is drilled and threaded between the tube holes which are cracked. This hole is usually about ¼ in. diameter and takes away most of the crack. It is countersunk on both sides if possible, which takes out the portion of crack above and below the peg stud hole and allows the stud to be riveted over flush with the plate. All the crack is thereby drilled away or filled with the head of the stud. A copper liner is then inserted from the boiler side, expanded and beaded over on the fire-box side to cover part of the countersunk head of the peg stud. The tube is then inserted and beaded over the liner beading.

Frequently tube plates are found to be cracked between the top row of small tubes and the bottom row of superheat tubes. The small tube hole in this case is threaded and a brass plug inserted. Prior to this plug being riveted, the peg stud is fitted and riveted, after which the head of the brass plug is formed to cover part of the peg stud. A copper liner is then inserted in the superheat tube hole with its beading resting on the upper portion of the stud. The brass plug is then bored to receive a tube with a reduced end, which allows a good thickness of bush. The tubes are then fitted and beaded. Sometimes owing to the thickness of the bridge being much reduced, the small tube is dispensed with and a solid plug inserted. The peg stud in this case is inserted after the plug has been riveted, and fits partially into the plug and partly into the plate. The head is riveted into the crack and into a recess formed in the head of the solid plug.

Where a crack does not extend from tube hole to tube hole, the effect of fixing a peg stud prevents further development of the crack.

These methods of repairing tube plates give satisfaction in practice and delay renewals until perhaps other portions will need renewing or a new fire-box

Fig.10. METHOD OF REPAIRING FIREBOX TUBEPLATE CRACKED BETWEEN SUPERHEAT TUBEHOLES.

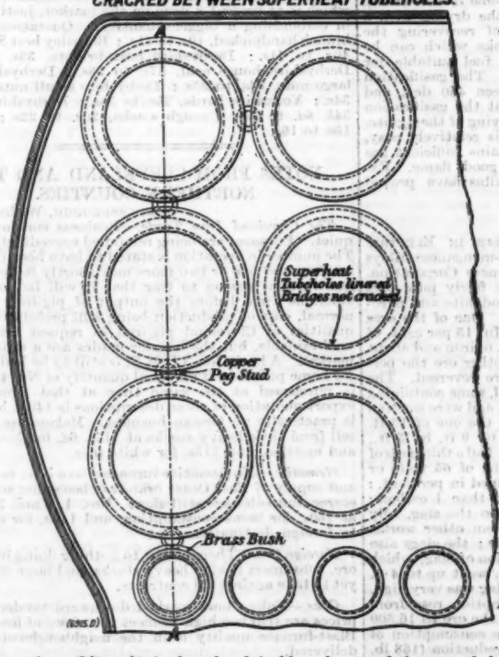


Fig.11. SEC. THRO' A-A.

is required. It is necessary that the work be carefully done. The liners which follow the rose-bit sizes must always be a good fit. After the liners are expanded, the tubes are ordered to the size obtained by callipers. This size should be accurate and the tubes made a good fit, or the peg studs will be disturbed during the process of fitting the tubes.

The principal trouble with this method of tube-plate repair is that expanding the tube often undoes much careful work. Good results have been secured by first of all expanding the tubes in the vicinity of the crack and then inserting the peg stud without removing the tube. To do this it is necessary to cut away a portion of the beading of the tubes in order to countersink the stud hole and allow of the stud head to be properly riveted in to the crack. This should not be done if the tubes require renewing.

Figs. 7 and 8 show the spindle and rose bit used for making the superheat tube holes true. A number of these rose bits are stocked, the sizes ranging from $4\frac{1}{32}$ in. to 5 in. in $\frac{1}{32}$ of an inch, and all fitting on the standard spindle.

The liners are made of copper turned to size with one end flanged, as shown in Fig. 9. They are about $\frac{1}{8}$ in. thick and are used instead of a screwed bush, as the screwing of large tube holes in a confined space is not practicable. When beaded over on both sides of the tube plate they substantially stiffen and support the bridges. Figs. 10 and 11 show a portion of a tube plate repaired by the peg stud and beaded liner method.

A 1000-HORSE POWER MOTOR FOR AIRCRAFT.

Being under the impression that aeroplane motors are still practically automobile engines of light weight, the designers of which do not appear to be sufficiently informed on the particular problems of aircraft propulsion, Dr. Ing. Edmund Rumpler departs in several important respects from current practice in his design of a 1,000 h.p. Motor for Aircraft. He explains the design of such a motor and the calculations, upon which the design is based, in a small quarto volume of 63 pages, fully illustrated by 24 plates and tables, on "Der 1,000 PS Flugmotor," which is edited by the *Wissenschaftliche Gesellschaft für Luftfahrt* and published by Messrs. Oldenbourg, of München (price 50 marks). It does not appear that any motor of this type has yet been constructed; the publication may be made for the purpose of eliciting critical comments; but Dr. Rumpler contents himself with a description and a summary of his calculations.

He characterises his motor as a combination of the series and star arrangement. He groups four stars, *i.e.*, four radial sets each of seven stationary cylinders, about a common crankcase, the whole arrangement being strictly symmetrical. Four of these cylinders, one from each star, form at any moment the normal four-cylinder series motor. The common shaft rests in five bearings. On each of the four crank pins act seven connecting rods, one direct main rod and six rods with indirect connection, the latter being linked to the main rod; the main rod is divided, one end of its shaft being developed into a half-bearing over which a kind of marine-head cover is mounted; the rods are made of nickel steel. The piston is made of aluminium, but provided with a steel shell which is screwed on the aluminium body. The crank case consists of four parts, circular in section; each of these parts is cast in one piece together with the seven cylinders of the particular star, the conical water jacket of the cylinder being combined with this casting. The cylinder material, aluminium, is hardened as will be explained later. The radial grouping of the cylinders is such that there are four cylinders behind one another, in any of the seven lines parallel to the common shaft. Each cylinder head has four valves, two for inlet and two for exhaust. There are thus $4 \times 7 \times 4 = 112$ valves; to simplify their operation, the four cylinder heads of a series are joined together, the tubular connection enclosing a telescopic gearing. There is an inner shaft and concentric with it are shorter lengths of three other shafts, running in roller bearings. A toothed gear on the common crankshaft drives four discs each fitted with three cams, and each actuating the seven cylinders of a star. The rear disc actuates the innermost shaft and through it the front cylinder; the second disc actuates the smallest hollow shaft and second cylinder, and so on.

The oil pump is driven by an eccentric and is provided with a step piston, the valves being so arranged that the smaller portion of the piston acts as a suction pump, whilst the wider portion serves as a delivery pump. The gasified fuel circulates in an annular channel of the crank case. The ignition is effected by means of two magnetos, which are independent of each other, but have a common connection with the distributor; the magnetos are worked by gearing at three-and-a-half times the speed of the crank shaft, so that two revolutions of the crank shaft give $4 \times 7 = 28$ ignitions. The connection between the crank-shaft and the propeller shaft comprises ball thrust bearings which prevent the transmission of the thrust from the propeller to the motor.

Other characteristic features could not profitably be described without rather full illustrations. We will only mention the way, above alluded to, in which the inner walls of the aluminium cylinders are hardened. This is done by forcing a small steel tool in a helical path through the cylinder. The pitch of the helice is 0·1 mm. and the width of the (overlapping) tool is 0·2 mm.; with a pressure of 1,000 kg. on a cylindrical surface element of 1 cm. width the actual pressure on the narrow part of the cylinder under compression will be 10 kg., which the aluminium can well bear. The total length of the complete motor is to be 1,600 mm. (63 in.) and the diameter 1,210 mm.; the cylinder stroke and diameter are both fixed at 140 mm. (5·5 in.). A speed of 2,000 r.p.m. is expected. The probable weight is not stated, although the reduction of weight is said to be one of the objects of the design. Small consumption of oil and water, with effective balancing of the masses and moments and high efficiency, are other advantages anticipated by Dr. Rumpler. The force and equilibrium problems are solved by graphical methods.

1921 Tractor Trials.—The Society of Motor Manufacturers and Traders, Limited, second International Tractor Trial and Power Farming Exhibition opens on September 20, at Shrawardine, near Shrewsbury, and continues until September 24, inclusive.

Electric Power in Switzerland in 1920.—The number of projects submitted to the electric power section of the Swiss Railway Department in the year 1920 amounted to 2,598, against 2,389 in the year 1919. Of these projects, 939 concerned transmission lines and 659 the machinery, transformers, &c. Of the projected transmission lines 602 are to carry high-tension current and 1,307 low-tension current. The length of the new high-tension lines actually erected was 875 km. (544 miles; 582 km. in the previous year)—comprising 54 km. (34 miles) of underground cable; 670 km. (416 miles) of the aerial lines were copper wires, 80 km. (50 miles) being of aluminium (against 167 km. in 1919). The machinery projects referred to 14 new generation stations; only one of these projects required machinery of more than 200 kw. Most of the other projects were limited to transformers, converters, &c.

Partly-Coked Lignite as Powdered Fuel.—Ordinary lignites are too damp, and their transport in the dried condition is too difficult to make powdered lignite a good fuel, especially as the calorific power is low to start with. Moreover, the by-products are lost when the lignite is burnt in the ordinary combustion chamber. According to Dr. Dolch, of Vienna (*Oesterreichische Monatschrift für Bradienst* and *Berg-und Hüttenwesen*), it is, however, possible to combine the drying with a partial gasification, which admits of recovering the by-products while yielding a semi-coke which can be ground down to make a powdered fuel suitable for injection into combustion chambers. The gasification temperature recommended lies between 450 deg. and 500 deg. C., and Dolch considers that the gasification would not cost much more than the drying of the lignite. The disintegration of the semi-coke is relatively easy, and the powdered material still contains sufficient gas to ignite readily and to produce a good flame. Experiments made in rotary cement kilns have proved satisfactory.

Production of Silicon-Manganese in Electric Furnaces.—In manufacturing silicon-manganese alloys during the war the Southern Manganese Corporation, of Anniston, Alabama, had to utilise fairly pure ores and silica rock, special minerals like rodonite and pyrolusite and quartz not being available. One of the ores used contained about 33 per cent. of Mn, 15 per cent. of silica, 4 per cent. of Al_2O_3, 2·4 per cent. of iron and about 3 per cent. of alkaline earths; in another ore the percentages of manganese and silica were reversed. The ores were mixed with a bituminous coal, some containing up to 10 per cent. of alumina, and coke, and were smelted in two rectangular open-top furnaces, the one of 15 ft. by 7½ ft. by 7 ft., the other of 18 ft. by 9 ft. by 5 ft., lined with carbon which in the bottom had a thickness of 2 ft. or 2½ ft., by three-phase currents, of 65 volts or 100 volts. The alloy produced contained in per cent.: 65 manganese, 21 silicon, 13 iron, less than 1 carbon; 5·21 per cent. of manganese went into the slag. By 1918 this slag, together with slags from other works, formed the chief raw material available; the slags also gave a fair alloy, though the proportion of slag, which at first was 2·6 tons per ton of alloy, went up to 4·5. The recovery of manganese from the slag was very high, 96 per cent., but the current consumption rose from 10,000 kw.-hours per ton of alloy with the ore to 16,500 kw.-hours per ton with the slag. The consumption of carbon for the electrodes and the ore reduction (168 lb. and 1,715 lb. per ton of alloy) was likewise high; but the current estimates are only rough, and economy could not be studied. The slag was kept free-flowing in general, though it was sometimes sluggish; the tapping are was not wanted even when a special alloy, high in silicon (20 per cent. of manganese, 50 per cent. of silicon 30 per cent. of iron) was being made. The alloys were always practically free from calcium, aluminium and magnesium. As regards the use of silicon-manganese in steel refining, Mr. B. G. Klugh, who described these operations (American Electrotechnical Society, Transactions, vol. xxxv, pages 401 to 410), refers to Professor Samuel L. Hoyt, whose excellent book on "Metals and Common Alloys" we reviewed on page 229 of our issue of August 5 last. Hoyt recommends silicon-manganese alloys because they yield sound and clear steel castings. The foundryman does not like to have to use several refining alloys; standard silicon-manganese alloys would probably be appreciated, if one alloy should prove insufficient.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—The promised revival finds very little reflection in the condition of trade locally. A certain measure of hope is drawn from the fact that inquiries for steel products of special quality are more numerous, particularly from Continental buyers. The volume of business actually booked, is, however, discouraging. In every section of the engineering trades manufacturers are endeavouring to reduce costs. These efforts, supplemented by a wider spirit of co-operation among the most representative trade unions, are proving successful. The main problem, that of fuel cost, remains unsolved. Whether the general abstention of steelmakers from entering into contract business will in the end compel collieries to reduce the price of manufacturing fuel to within the neighbourhood of 20*s.* per ton is uncertain, but the fact that the continued accumulation of slacks and smalls at pitheads is causing increasing difficulty in production generally, is calculated to have an early effect on prices. A slight increase is reported in the local output of acid and common steels, but for the most part this is due to the working off of old orders. Very little pig-iron of British manufacture is coming into the district. Blast furnace masters can buy Swedish material at little more than the labour cost in this district. Depression in the special steel section continues to exercise a sluggish influence on purchases of alloys. The rolling mills are turning out a small tonnage for the automobile and agricultural industries. No new orders of any considerable magnitude have been booked for electrical equipment. Benefit is expected to accrue locally from the Admiralty's decision to build four capital ships. It is regarded as certain that a fair proportion if not the bulk of the work, will be placed with Sheffield armament firms possessing shipbuilding connections. Big orders for files are merely being held over pending a suitable price reduction. An inquiry from Brazil mentions 20,000 dozen.

South Yorkshire Coal Trade.—Business in house coal has fallen off considerably. The reason attributed by representative merchants is that many families are away on holiday, and that potential buyers have an eye on possible price reductions. The tonnage going to railway companies tends to increase. Gas works and electricity concerns have made good progress in replenishing diminished reserves. On manufacturing account, the demand is far from satisfactory. Collieries are producing a bigger tonnage of slacks than they can dispose of. The slump in slacks is likely to continue until the demand for coke, which is at present a drug on the market, justifies users in carbonising a bigger quantity. Quotations:—Best branch handpicked, 40*s.* to 41*s.*; Barnsley best Silkstone, 40*s.* to 41*s.*; Derbyshire best brights, 38*s.* to 39*s.*; Derbyshire house coal, 37*s.* to 38*s.*; Derbyshire best large nuts, 34*s.* to 35*s.*; Derbyshire small nuts, 33*s.* to 34*s.*; Yorkshire hards, 35*s.* to 36*s.*; Derbyshire hards, 34*s.* 6*d.* to 35*s.*; rough slacks, 20*s.* to 22*s.*; smalls, 15*s.* to 16*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—Business continues very quiet. Furnaces are being rekindled exceedingly slowly. The number in operation is stated to have been increased to nine, and one or two more may shortly be re-started, but there is reason to fear that it will be some considerable time before the output of pig-iron is again normal, cost of production being still prohibitive. The qualities of Cleveland pig-iron in request are almost unobtainable, but the inferior grades are a drag on the market. A little No. 3 G.M.B. is still to be had at 135*s.* for home purposes, if an equal quantity of No. 4 foundry is purchased at the same time at that figure. The export quotation of these descriptions is 140*s.*, but there is practically no foreign business. Makers are keen to sell from their heavy stocks at 117*s.* 6*d.* for No. 4 forge and mottled, and 115*s.* for white iron.

Hematite.—No hematite furnaces have been re-started, and supply of East Coast brands is becoming somewhat scarce, but sales are still slow. Nos. 1, 2 and 3 remain at 160*s.* for home consumption, and 140*s.* for despatch to foreign destinations.

Foreign Ore.—There is next to nothing doing in foreign ore, consumers having heavy stocks, and large deliveries yet to take against old contracts.

Coke.—Coke shows marked downward tendency, but prices are still too high to meet the views of local users. Blast-furnace quality is in the neighbourhood of 40*s.* delivered.

Manufactured Iron and Steel.—Prospects in the finished iron and steel trades are not encouraging. Recent price cuts have not stimulated business, and further fall in values seems essential. Black sheets have been lowered 30*s.*, and galvanised sheets 40*s.* Principal market quotations stand:—Common iron bars, 16*l.*; marked bars, 20*l.*; steel billets, 12*l.* 10*s.* to 13*l.*; steel boiler plates, 21*l.*; steel ship, bridge and tank plates, 15*l.*; steel angles and joists, 14*l.* 10*s.*; heavy steel rails, 14*l.*; and fish plates and sleepers, 19*l.*

Cleveland Ironstone Miners' Wages.—The Cleveland ironstone miners have accepted the offer of the mine owners to pay the present base rate plus 123·7 per cent., with a minimum of 8*s.* per day for datal labour, the new terms to be operative for three months. The new terms represent a drastic reduction on wages paid at the beginning of the year. Before the recent offer was made the miners had accepted this year decreases amounting to 5*s.* a day.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—There has been little change of any note in the Scottish steel trade during the past week, and the market continues very depressed. Work generally has now been resumed, but on the whole the order books are not very full. One or two firms have a fair amount of work booked but these are the exceptions, and most of these orders are for special lines, the majority of which could be very quickly turned out were normal conditions prevailing. During recent years the output capacity of nearly all the steel works in this area has been greatly increased, and at full pressure a very large tonnage can be produced, but owing to the adverse circumstances now prevailing outputs to-day are far below those of the past year or two. As soon as fuel permits of cheaper hematite, &c., and wages generally decline, the steelmakers are almost bound to get much busier as, many consumers are understood to have quite substantial contracts to place, but these are being held back for cheaper prices. The demand for ship plates and sections is very poor owing to the falling away in shipbuilding orders. The general inquiry is far from good and consists to a large extent of feelers. The following are the current quotations: Boiler plates, 20*l.* per ton; ship plates, ½ in. and up, 15*l.* per ton; sections, 14*l.* 10*s.* per ton; and sheets, $\frac{7}{16}$ in. to ½ in., 16*l.* 5*s.* per ton, all delivered at Glasgow stations.

Malleable Iron Trade.—In the malleable iron trade of the West of Scotland a very dull quiet tone prevails and business is of a hand-to-mouth character. Orders have not been accumulating to any extent during the recent stoppage, and fresh business is a trifle difficult to pick up. Prices are unchanged, but in the hope of inducing buyers to give out new contracts there is quite a probability of quotations being lowered on an early date, but in the meantime "Crown" bars are called 16*l.* per ton, delivered on rail at Glasgow.

Scottish Pig-Iron Trade.—The production of pig-iron in this district is still in abeyance, but there are prospects of some furnaces being relighted shortly. Business is very quiet, and stocks still on hand in makers' yards are equal to all demands so far, but prices keep high. Certain qualities of foundry iron being off the market, consumers are using the Continental make which is coming in freely just now. Not only is the home demand very small, but there is also practically nothing doing in export. Hematite is round 9*l.* per ton delivered at the local steel works, and foundry iron, No. 1 quality, is about 8*l.* 15*s.* per ton, with No. 3 at 8*l.* 10*s.* per ton, both loaded into trucks at makers' works.

ELECTRIC STEEL FURNACE IN THE PHILIPPINES.—The New York journal, *The Iron Age*, reports that according to the *American Chamber of Commerce Journal*, Manila, P.I., the Atlantic, Gulf and Pacific Company will very shortly have an electric steel furnace completed. It is the first installation of its kind in the Philippine Islands, and will be used for manufacturing steel castings required for machines in the cane sugar industry.

WHEELS AND AXLES.—An unusually creditable piece of commercial literature has been produced by Messrs. William Beardmore and Co., Limited, in the form of a catalogue dealing mainly with their manufacture of railway wheels and axles. The catalogue opens with a brief historical review of the firm, but its main contents are a series of most excellently reproduced photographs with appended descriptions showing the various steps in the process of wheel and axle-making as carried out at their works.

A COLLEGE-BUILT ELECTRIC FURNACE.—According to *The Iron Age*, a 60-kw. electric brass-melting furnace of 200-lb. capacity, designed, built and operated by students, has recently been installed in the chemical engineering laboratory of the College of Engineering, University of Wisconsin, at Madison. This is believed to be the smallest commercial furnace of this type in the United States, and the State University is the only institution of its kind which possesses such a unit. The shell and mechanical parts were made in the university mechanical department; the fire-resisting sand was produced in an electric resistance furnace in the chemical engineering laboratory. The foundation and lining were built entirely by students. The actual cost is said to have been 350 dols. compared with a market price of 1,000 dols. for a commercially-manufactured unit.

COOLING COILS FOR DIESEL ENGINES.—At a recent meeting of the Diesel Engine Users' Association, the question of the wear and bursting of the cooling coils used in connection with the air compressors of engines of this type formed the subject of a paper read by Mr. C. O. Milton. The author was of the opinion that the chief factor in the deterioration of these coils was the presence of moisture in the air, and he advocated the utmost attention being given to the draining of the compressors between stages. The extraction of suspended water from the air, at the discharge valves, was considered likely to preserve both coils and main piping and the receiver system generally. The supply of lubricating oil should also be kept to a minimum. The loss of weight, up to 25 per cent. of the original weight of a coil, was a fair guide to its reliability, but intervals between weighings should be short enough to detect any sudden increase in the deterioration of the coil.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Irregularity and uncertainty are the predominant characteristics of the Welsh coal trade. Prices have fallen from 6*s.* to 15*s.* per ton compared with a month ago, and buyers are still pursuing a waiting policy in the anticipation that values will go yet lower. Tentative inquiries are numerous, but actual business is small. This, coupled with the fact that outputs have exceeded anticipations, causes colliery salesmen difficulty in disposing of available supplies even at the reduced figures, and to keep pits working regularly they are prepared to make sacrifices. A few weeks ago Admiralty large coal commanded 50*s.* and best Monmouthshires 52*s.* 6*d.*, but it is now possible to secure these grades at less than 40*s.* Dry large is also freely available at between 35*s.* and 36*s.*, compared with 47*s.* 6*d.* a few weeks ago, while best steam smalls, which commanded up to 30*s.* are selling at 20*s.*, and in some cases 19*s.*, with ordinary smalls round 17*s.* 6*d.* and inferior dry smalls down to 15*s.* Good throughs can be purchased at 27*s.* 6*d.*, compared with 37*s.* 6*d.* in July. Though it is quite possible that the market has not yet touched bottom, colliery salesmen are now proceeding cautiously and making a stand against further reductions declaring that in view of the absence of definite information concerning production costs they prefer to let the pits remain idle rather than work at a loss. Foreign cargo exports in the past week at 164,406 tons were 70,000 tons less than in the preceding week, due to the intervention of the August Bank Holiday and the stoppage of work at the pits and the docks for a day. Shipments to France amounted to 50,000 tons, Italy 33,000 tons, South America 26,000 tons, Spain, 15,000 tons, Portugal 12,000 tons, Greece 4,000 tons, British coaling depots 13,000 tons, and other countries 11,000 tons.

Iron and Steel.—Business has been restricted and prices are lower. Works have of late been manufacturing for stock and in the belief that prices are falling supplies have been thrown on the market and values have receded 2*s.* per box on the week. Forward plates are down to 22*s.* 6*d.* f.o.b. and it is calculated that taking Welsh bars at 9*l.* 10*s.* per ton this means a loss of about 3*s.* per box. A substantial drop in the wages of tin-plate operatives has come into operation as a result of the reduction in the average price of bars in the three months ending June. The new rate for the next three months will be 45 per cent. plus the 25 per cent. consolidated rate, which equals 81¼ per cent., against 131¼ per cent. ruling in the past three months.

UNITED STATES ZINC PRODUCTION.—The statistics of the United States Geological Survey show that country's zinc production to have increased approximately 32 per cent. in the period from 1914 to 1919. In 1919, the production was 465,743 tons; in 1914 it was 353,743 tons. In all states the total number of establishments was 29 in 1914 and 38 in 1919.

SMALL-SIZE GAS PRODUCER.—The Liliput gas producer of the Gasmotoren-Fabrik Deutz is cast in one piece with the base of the purifier, and supports the upper cylindrical portion which is charged with coke. The advantage of the one casting is that the pipes and pipe connections are replaced by ducts and ports, and that the weight is kept low. The ring plates of the step grate can be turned on the balls on which they rest. Water drops down upon the rings; there are no preheaters or warm-water tanks. The Liliput suction-gas apparatus are built for producing from 10 cub. m. to 85 cub. m. of gas per hour, sufficient to yield from 4 horse-power to 35 horse power. In tests made at the Zentrale für Koksverwertung, in Berlin, the consumption of German anthracite, in lumps less than 1 in. in diameter, was 0·562 kg. per horse-power-hour, when the 6-h.p. motor was developing 7·24 h.p. for 7 hours. Even when not utilised to its full capacity, power from such suction gas installations, it is claimed, might well compete with power from electric mains.

TWO HUNDRED AND FIFTY YEARS OF BLAST-FURNACE OPERATIONS AT WASSERALFINGEN.—The iron works at Wasseralfingen, in Württemberg, which have now been in existence for two hundred and fifty years were not the first ironworks of Württemberg, which is not conspicuous among the iron-producing countries. But the name of von Faber du Faur, who was manager of these iron works a century ago, is well known, and his suggestion of utilising the blast-furnace gases for generating heat and power, made Wasseralfingen famous. The ore utilised in these districts is the oolitic iron ore (Bohnerz) of the Suabian Jura. The first Württemberg iron works mentioned, in 1365, are those of Königsbronn; there had been an iron industry in that part many centuries before. At Wasseralfingen the blast furnaces were, like those of Königstronn, the property of monks, of the Ellwangen Abbey, and the works remained connected with the church until the monasteries were taken over by the State during the Napoleonic wars. At that time Alfingen had two furnaces and a foundry, and employed 15 men. When Faber du Faur came in 1811, the development was rapid, and the art castings due to Konrad Weitbrecht and Plack enjoyed a reputation far outside the country. English engines were put up in 1844; coke partly replaced charcoal in 1861, but in 1876 three charcoal furnaces were still in operation. Slack times set in later when mild steel threatened the wrought iron made at Wasseralfingen, and the war almost killed the works. Since last spring the furnaces have been making a grey foundry iron, especially for heavy castings.

NOTICE OF MEETING.

THE MINING INSTITUTE OF SCOTLAND.—Saturday, August 13, at 3 p.m., General Meeting in the Royal Technical College, George-street, Glasgow. The following papers will be open for discussion: Mr. H. M. Cadell's paper on "Coal-Mining in Spitzbergen"; Professor Brigg's paper on "Physical Work and the Human Machine"; and Mr. William McNaught's paper on "The Beam Electric Head-Lamp." A paper by Mr. David Penman, B.Sc., will be read on "A New Method of Measuring Ventilating Resistances, with Special Reference to the Operation of Mine Fans in Combination."

BRITISH ASSOCIATION ENGINEERING SECTION PROGRAMME.

THE British Association, as already announced, will meet at Edinburgh, on September 7 to 14. The following is the programme of the Engineering Section G, over which Professor A. H. Gibson, D.Sc., will preside. The sectional proceedings will each day begin at 10 a.m. and be preceded by meetings of the Sectional Committee at 9.30 a.m. Papers to read on Thursday, September 8, 10 a.m.: Professor T. Hudson Beare, "An Inquiry into the Suitability of Scottish-grown Timber for Aeroplanes and Pit Props"; Professor Alexander R. Horne, "Experiments on the Mechanical Properties of Scots Pine"; Dr. B. C. Laws, "Stresses in Ship's Plating due to Fluid Pressures"; Dr. E. M. Horsburgh, "The Breaking of Wire in Steel Ropes"; Professor T. Hudson Beare, "Influence of the Width of the Specimen on the Results of Tensile Tests of Mild Steel and Rolled Copper"; Professor Henry Briggs, "Two New Rescue Apparatus (Oxygen-breathing apparatus)." Afternoon, visit to the wire mills of Messrs. Brunton, Musselburgh.—Friday, September 9: Presidential address of Professor Gibson, "Water Power"; Professor F. G. Bailey, "The Linking-up of the Smaller Water Powers of Scotland"; Professor F. C. Lea, "Tides as a Source of Power, with Some Reference to the Severn Scheme." Afternoon, visit to the works of Messrs. Bruce, Peebles and Co. (electrical engineering) and to Messrs. Ramage and Ferguson, Limited, Leith (shipbuilding).—Monday, September 12: Squadron-leader A. J. Miley, "Seaplanes"; joint discussion with Section C, Geology (in the rooms of "C") on the Mid-Scotland Canal. Afternoon, visit to the laboratories of the Heriot-Watt College.—Tuesday, September 13: Mr. Sidney B. Donkin, "Some Notes on the New Electricity Supply Station of the Corporation of Edinburgh for the Supply of the City and the Lothians"; Dr. S. P. Smith, "Large Electric Units (New Constructive Features)"; Mr. J. Scott-Taggart, "Two New Negative Resistance Devices for use in Wireless Telegraphy (Thermoionic Valves)"; Dr. T. F. Wall (Birmingham), "Long-Distance Transmission of Electric Energy with Special Reference to Tidal Power."—Wednesday, September 14: Dr. S. F. Barclay, "Modern High-Speed Centrifugal pumps"; Dr. J. S. Owens (London), "Experiments on Air-Lift Pumping"; Dr. David Ellis, "Iron Bacteria and the Incrustation of Pipes"; Professor C. E. Inglis, "Two-Dimensional Stress in Rectangular Plates"; Report of Committee on Complex Stresses (including several papers, by Professor E. G. Coker on Stress Concentration due to Notches and like Discontinuities, and by others). Afternoon, visit to Rosyth.

THE FORD MOTOR CAR COMPANY.—We read in *The Iron Age*, New York, that the June output of the Ford Motor Car Company in the United States was 108,962 passenger cars and trucks, which is an average of 4,190 cars for each of the 26 working days. This is the high mark in the history of the company, breaking the May record by 7,486. The schedule for July called for 109,000 cars and trucks. The sales department reports that the demand for closed cars has been exceptionally strong, but that all models are in greater demand than production facilities can provide.

IRON AND STEEL INSTITUTE.—As already stated in our columns, the autumn meeting of the Iron and Steel Institute will be held at the headquarters of the Comité des Forges de France, 7, Rue de Madrid, Paris, on Monday and Tuesday, September 5 and 6, commencing on Monday at 10.30 a.m. and on Tuesday at 10 a.m. At the conclusion of the meeting alternative visits have been arranged to works in Lorraine, in Burgundy and in Normandy. The following is the list of papers which it is expected will be submitted to the meeting: (1) Mr. N. T. Belaiew, "Damascene Steel"; (2) Mr. E. L. Dupuy, "An Experimental Investigation of the Mechanical Properties of Steels at High Temperatures"; (3) Mr. L. Guillet, "The Situation of the French Metallurgical Industry in the North and in the East of France; its Destruction and Reconstruction"; (4) Mr. K. Honda, "Does the Critical Point depend on the Strength of the Magnetising Field?"; (5) Mr. A. Portevin, "On Constituents found in Tungsten and Molybdenum Steels"; (6) Mr. A. Portevin and Mr. V. Bernard, "A Contribution to the Study of Coalescence"; (7) Mr. A. Portevin and Mr. P. Chevenard, "On the Characteristic Curves of the Heat Treatment of Steels"; (8) Mr. P. Nicou, "Iron Ore Deposits of Eastern and Western France"; (9) Mr. E. Schneider, "An Investigation of various forging operations carried out under Hydraulic Presses" (Part II); (10) Captain H. W. B. Swabey and Mr. R. Genders, "Manufacture of Shells in Canada during the War, 1914–18."

THE MACHINERY OF THE FRENCH TRANSATLANTIC LINER "PARIS."

CONSTRUCTED BY THE SOCIÉTÉ ANONYME DES CHANTIER ET ATELIERS DE ST. NAZAIRE.

(*For Description, see Page* 246.)

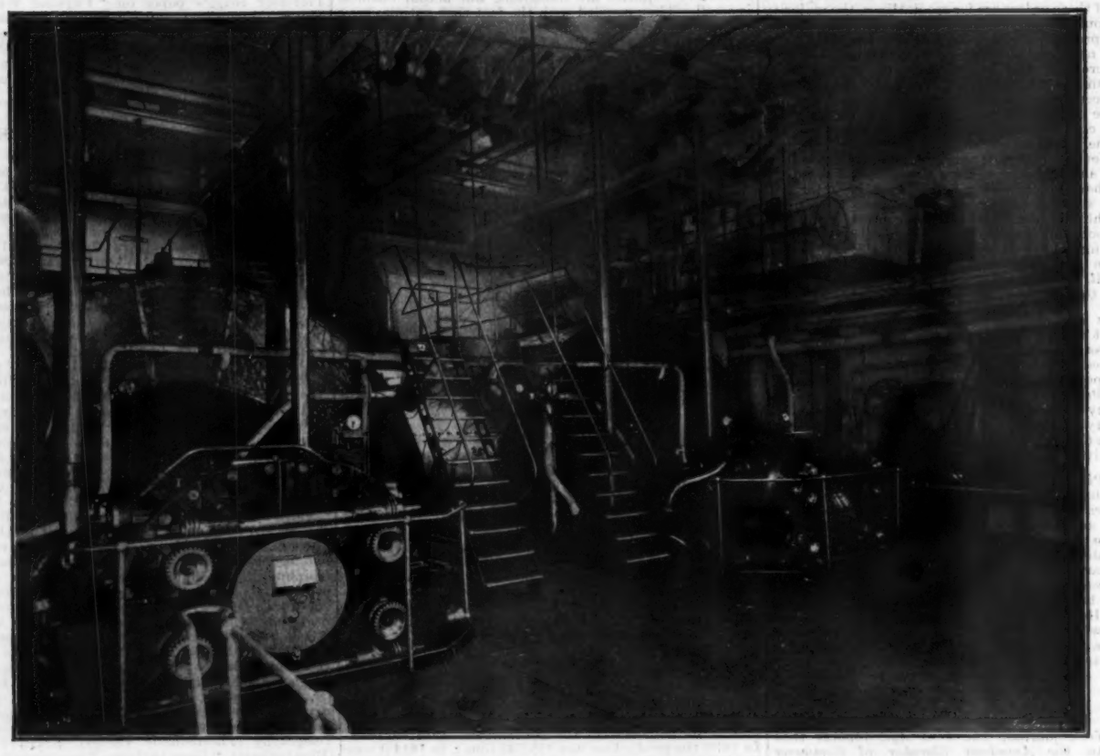


Fig. 38. Central Engine Room, Front View of the Two Low-Pressure Turbines.

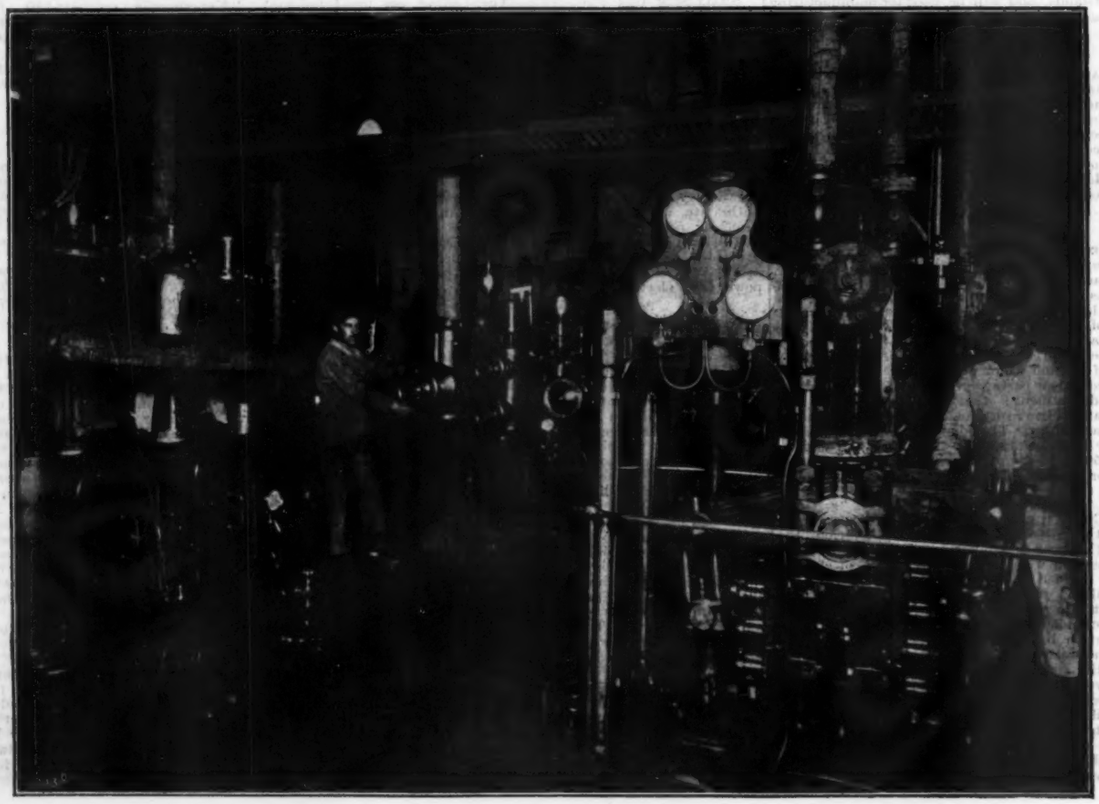
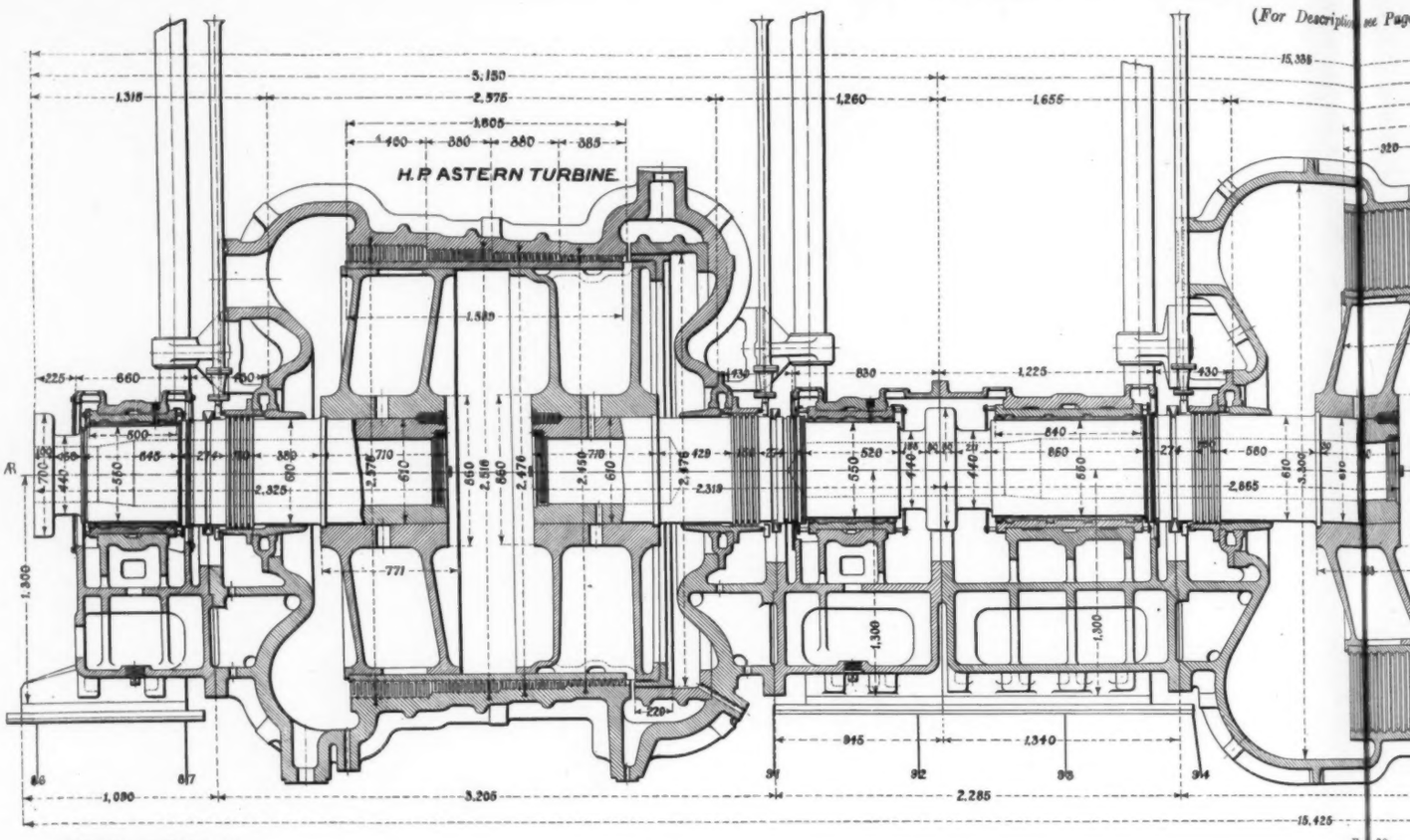


Fig. 39. View in an Auxiliary Engine Room.

MACHINERY OF THE TURBINE DRIVEN QUADRUPL

CONSTRUCTED BY THE SOCIÉTÉ ANONYME DE CHAN

(For Description see Page



SECTION AT FRAME 136

Fig. 21.

Fig. 20.

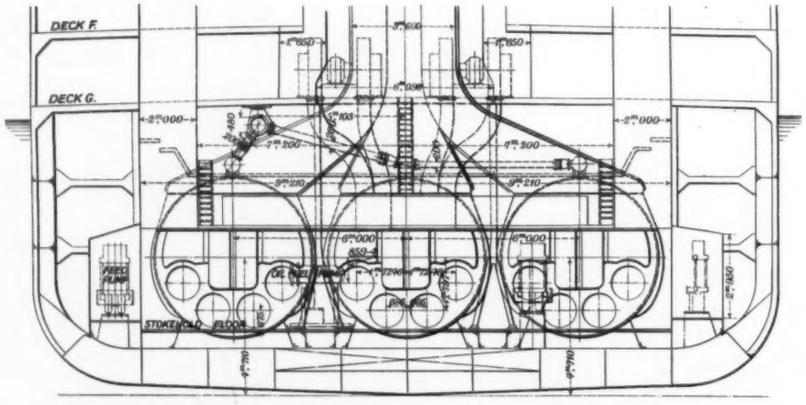


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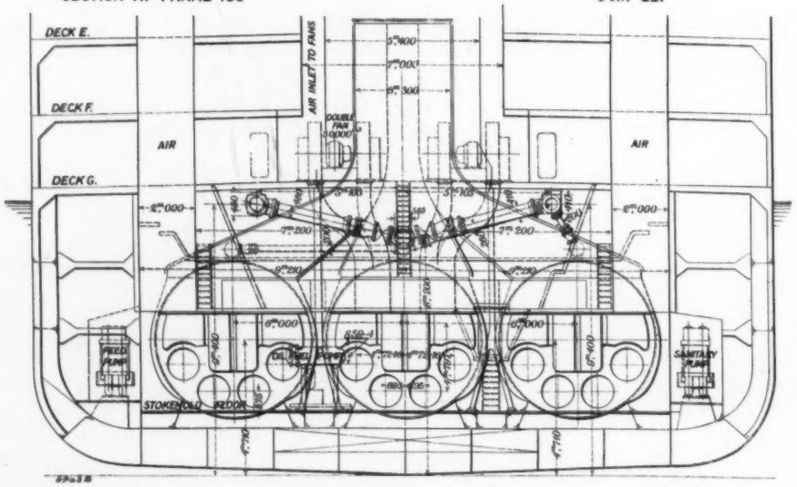
Fig. 22.



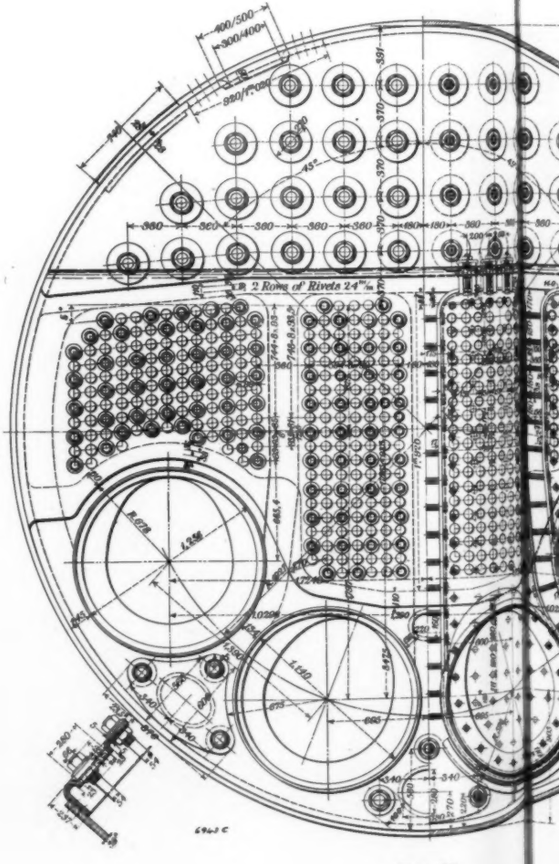


Fig. 23.

UADRUPLE-SCREW TRANSATLANTIC LINER "PARIS."

TME DES CHANTIER ET ATELIERS DE ST. NAZAIRE.

(Description Page 246.)

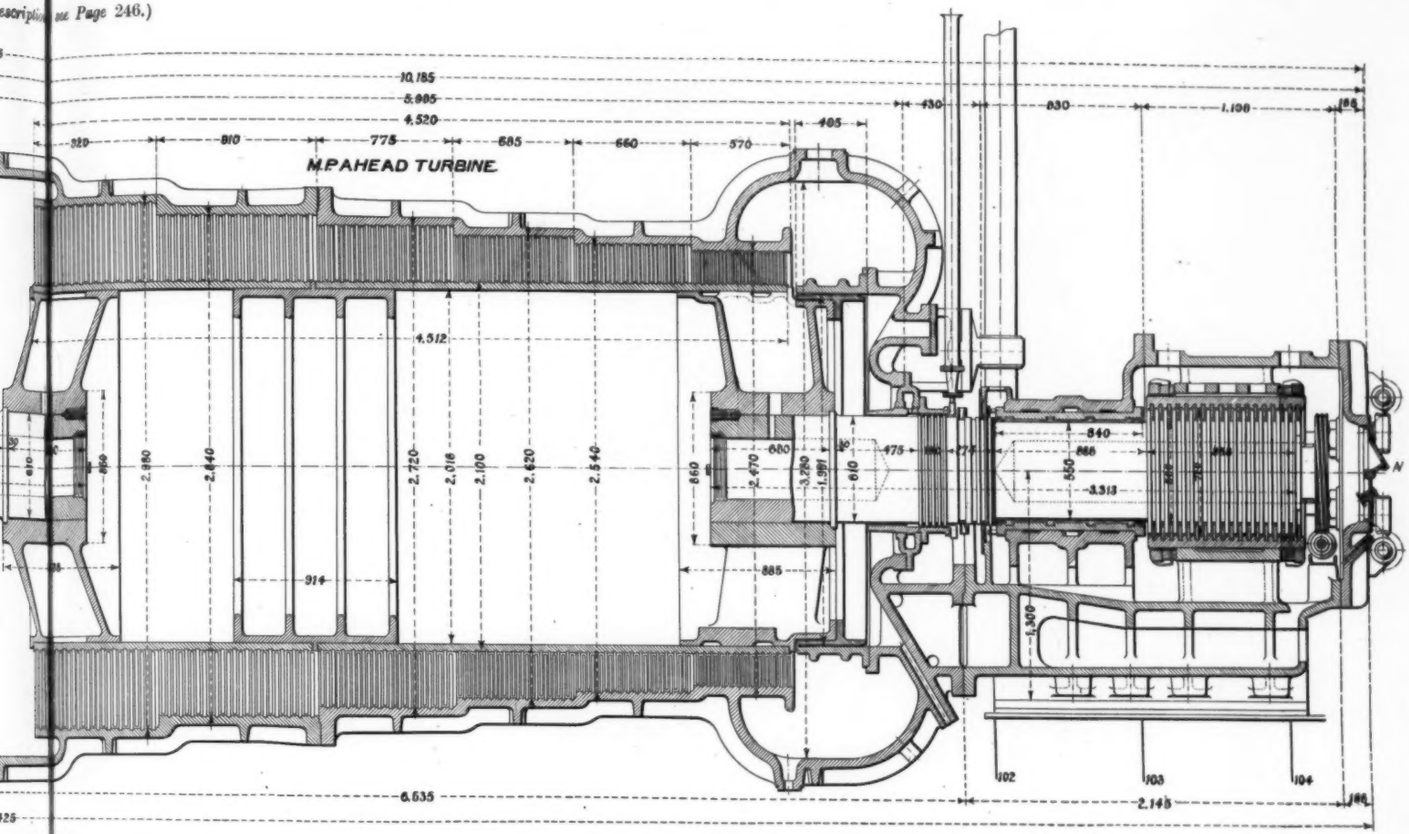


Fig. 20.

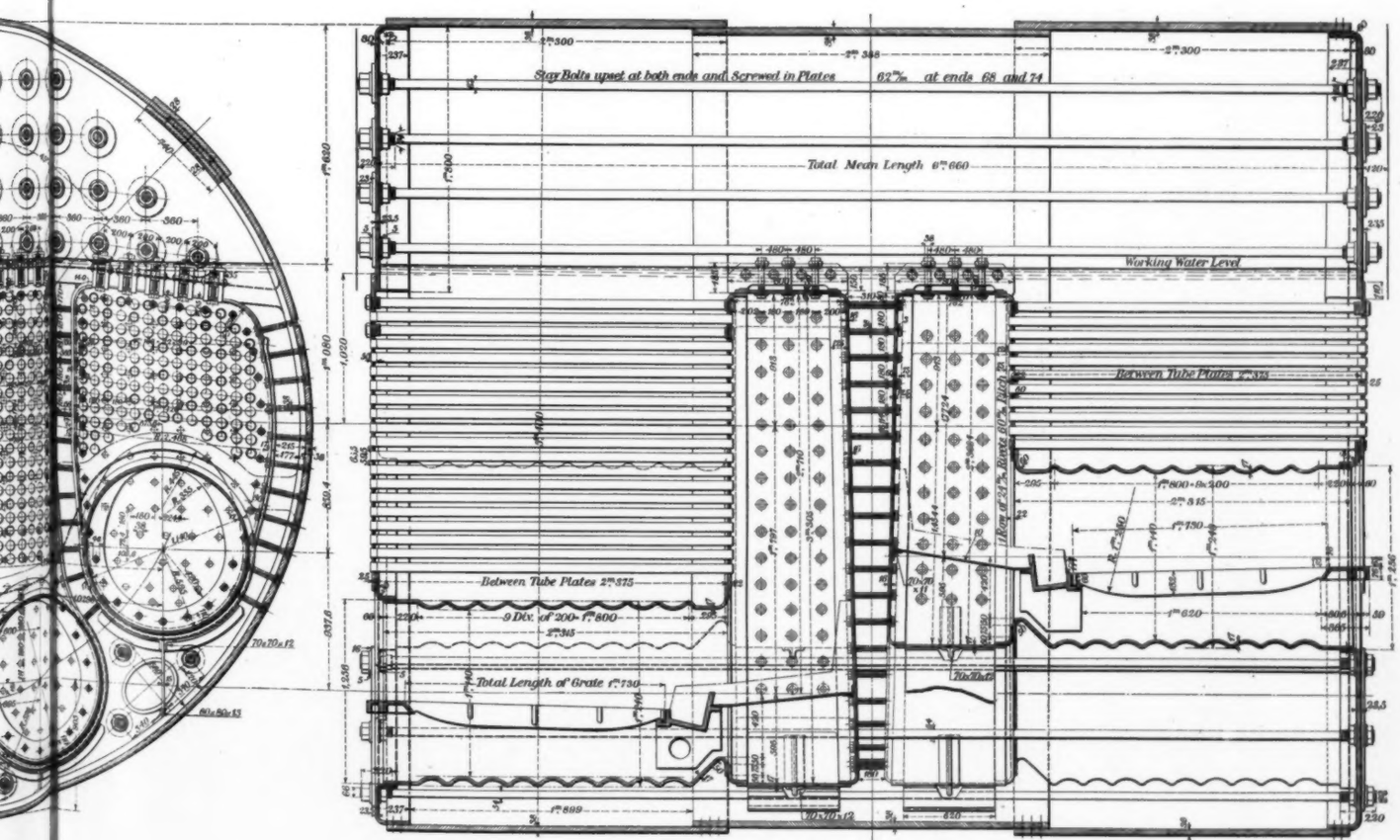

Stay Bolts upset at both ends and Screwed in Plates 62/m/m at ends 68 and 74
Total Mean Length 6m660
Working Water Level
Between Tube Plates 2m315
Between Tube Plates 2m315
9 Div. of 200= 1m800
Total Length of Grate 1m730

Fig. 24

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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12s. per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

SUBSCRIPTIONS, HOME AND FOREIGN.

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Thick paper copies	£3 3 0
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NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 253.

ENGINEERING.

FRIDAY, AUGUST 12, 1921.

THE YOUNGER MEN.

THE enormous variety of the activities which are now comprised under the general name of engineering has naturally tended towards the segregation of engineers into distinct classes, a segregation which is reflected in the numerous professional societies, each founded to further the special interests of some particular class. As specialisation increases, fresh societies continually arise in response to the demand of each group of specialists for an organisation devoted to their peculiar needs. This tendency would appear to be inevitable, and it is probably advantageous to the profession as a whole that the experts in each branch should have their own meeting ground where their particular problems may be discussed. But while such an arrangement satisfies the requirements of those who have reached maturity and settled down to a definite line of work, it hardly meets the case of the young man on the threshhold of the profession. Too early specialisation gives a narrow outlook, fatal to the development of the best type of engineering mind. The concentrated mental food of the specialist is unable to provide the all-round nourishment which is needed to build up a healthy intelligence, and the wider the field of engineering with which the neophyte becomes acquainted the more likely he is to achieve success in after life.

The needs of the younger men have for many years been catered for by the Junior Institution of Engineers, a society whose activities have frequently been favourably referred to in these columns. This, of itself, constitutes the greater reason why we find it incumbent to criticise adversely the proposal to alter the qualifications for membership and thereby to destroy the special "junior" character of the Institution.

"Founded in 1884 for the junior members of the profession," as, until recently, their official publications always reminded the reader, the Institution has attracted to its ranks the younger engineers of every branch, providing them with facilities for interchange of knowledge, social intercourse and other advantages of co-operative effort. It has laid itself out to occupy a field which the senior Institutions could not adequately cover, and the value of its work for the rising generation of engineers has been recognised by the number of eminent men, who as presidents or vice-presidents, have taken an active interest in its welfare. Its strength has always been derived from the fact that it has been conducted "by Juniors for Juniors." The members have managed it themselves under the most democratic of constitutions, and their youth and energy have been reflected in its numerous activities.

The advantages of an Institution which the younger members of the profession may regard as their own are very great. The sense of responsibility engendered by having to make their own decisions and abide by the results has a distinct educational value. The technical papers read at the meetings cover the whole field of engineering, and while they naturally approach the problems from the standpoint of the younger men, they often show a grasp of practical points which would do credit to societies of much greater pretensions. The discussions too are lively. In spite of the unfailing courtesy and encouragement extended to a youthful speaker at the meetings of the senior institutions, few young men can be induced to venture an opinion, or even to ask a question before an audience comprising the recognised leaders of the profession. But set them amongst their equals in age and experience, and they have no hesitation in saying what they think. Thus they acquire a readiness in debate and a power to express their thoughts audibly and without self-consciousness when surrounded by a sea of faces, which will serve them well on more important occasions in after life. A youthful audience will not tolerate prosiness or affectation from its equals, and it finds means of chastening bores (for their own salvation) which dignity forbids to a meeting of elder men. The art of public speaking, valuable though it be, is, however, a minor point. The main value of the Junior Institution is that it provides a technical and social centre for the youngest members of the profession, where they can meet under their own conditions, discuss their own problems and difficulties, and generally help themselves by helping each other.

Institutions, like other organisations, grow up and tend to lose their earlier characteristics with advancing years, but up to the present the Junior Institution has successfully retained the spirit of youth. Although an early rule that members on attaining the age of twenty-six, were compulsorily retired, was long ago abandoned, the Institution has remained openly and avowedly, the society of the younger men. Many of its earlier members, now by no means juniors in age, have continued to take an active part in its proceedings, but they have jealously guarded its early traditions. Befriended by influential engineers and others who recognised the value of its work, the Junior Institution has largely increased its membership of recent years, and numerous local sections have been started in this country and overseas. Prosperity is always the severest test of character, and there is reason to fear that the Institution is contemplating a step which will largely alienate the sympathy of those who have hitherto supported it on account of the special place it filled. Certain new by-laws have been drafted by its council for submission to the Board of Trade, the adoption of which will fundamentally alter the character of the Institution. Full membership in future is to be confined to "persons holding responsible positions in the engineering, or its allied professions," a restriction which subordinates the young men for whom the Institution was founded, to their elders, and at once brings the Institution into direct competition with the senior technical societies. It becomes, in fact, indistinguishable in its aims and objects, from the senior institutions, and withdraws from a field where it was doing excellent work to enter one in which there is absolutely no room for it.

We sincerely hope, in the interests both of the Institution itself, and of the young men who are entering the profession, that the proposed change in its constitution will not be consummated. It would be a false step, and practically an irrevocable one. There are amply enough societies, already, for the needs of "persons holding responsible positions," but there is only one which has had for its single object, the benefit of the younger men. The senior societies have always looked kindly on the self-reliant efforts of the Junior Institution to meet the intellectual and social needs of its members and to provide for the apprentice, student and junior draughtsman, the facilities, which in the nature of things, they themselves could not offer. This sympathy has been of immense practical value, but it can hardly be continued to an institution which sets itself to compete, however ineffectively, for membership with them. Moreover, the Junior Institution will suffer seriously by losing its attraction for the men who form its real strength. They cannot be expected to regard it in the same light as at present, when they are excluded from all possibility of full membership. There is much sentimental value in a name, and rightly or wrongly, the younger members will feel that they are subordinated to those whose proper place is in other institutions.

Another proposed rule, bearing upon future membership, emphasises the change in status which the Institution is seeking to obtain, and also involves a result which we should imagine was hardly contemplated by those who drafted it. It defines associate members as "persons between eighteen and twenty-six years of age, who are preparing to enter, or are occupying junior positions in the engineering or its allied professions. No person shall continue as an associate member after the attainment of his twenty-sixth year." The intention of the last sentence is, we understand, to

compel a member to pay fees on the higher scale after he is twenty-six years old. This is not unreasonable, but, as the clause stands, the council will be compelled, either to elevate him to the rank of full member at that age, regardless of whether he holds a "responsible" position or not, or to remove him to the class of associates, or to erase his name from the roll altogether. It would have been much simpler and more to the point to make the fees higher after a certain age.

The criticisms we have had to make upon the present policy of the Junior Institution are inspired by a feeling that the council are embarking on a course which we are convinced is against the best interests of the younger members of the profession. The Institution has won for itself a distinct place amongst technical societies, and it would be a thousand pities for it to destroy its usefulness and influence in an attempt to become something other than it is. The gift of eternal youth is too priceless a possession to be bartered for a meretricious dignity, and the tradition of "by juniors for juniors" should be resolutely adhered to. Finally, we may point out that the prizes and awards, and the donations to its funds which generous well-wishers have bestowed on it, have been given under the impression that assistance was being rendered to an organisation whose primary object was to benefit the younger engineers. The same feeling inspired the kindly regard which has caused so many firms to entertain the members and permit them to inspect their works. The Institution, we fear, is risking the sacrifice of these invaluable privileges by a mistaken policy, and is abandoning a heritage built up by the efforts of the young men of a generation ago.

THE COMMERCIAL SITUATION IN AUSTRIA.

The present Austrian Republic contains about one-eighth of the area and one-eighth of the population of the late "ramshackle" Empire. Its area is some 36,000 sq. miles, that is, twice the size of Switzerland and nearly three times the size of Belgium. The census taken in 1920 places the population at 6,067,000. These figures do not include Western Hungary, which is to be annexed to Austria under the Peace Treaty, but which is still administered by Hungary. More than one-third of the area of the country is forest land, while more than one-tenth is unproductive high mountain region. About half the area was in cultivation before the war. The proportion is now less. Vienna —the capital—has a population of 1,842,000, as compared with 2,031,000 in 1910, and an estimated population of 2,132,000 in 1913. Ninety-five per cent. of the inhabitants of the country are German speaking.

Economically, as is only too well known, the position of the country is most unsatisfactory. Owing to the depreciation of the currency the debt figures do not to an English reader give any immediate idea of values, but the condition of affairs is represented clearly enough by the fact that while the last financial year ended with a deficit of 10,000,000,000 crowns, the deficit for this year is estimated at 40,000,000,000 crowns, while Mr. O. S. Phillpotts, Commercial Secretary to H.M. Legation in Vienna, suggests that the figure may reach 60,000,000,000 crowns. The position is even worse than these figures indicate since the cost of the food brought in under allied credits is not included in the expenditure, but the receipts from its sale are entered with the income. This state of affairs is by no means to be attributed merely to the war debt of the old Empire, although in many quarters it is considered that Austria has to bear an excessive proportion, of the total under the Peace Treaty. This debt amounting to 39,000,000,000 crowns is considerably less than one-half of the 90,000,000,000 of debt which the country has incurred since the termination of the war.

The present condition of Austria is in great measure due to the break-up of a more or less homogeneous organisation into a number of small parts. Mr. Phillpots states that this is represented in Vienna as a consequence of the Peace of St. Germain, but actually the break-up of the old monarchy took place before the armistice and before the Treaty was drafted. Austria at the present time is in effect a manufacturing country with no raw material and no coal, but with happier relations existing between her and her new neighbours such as Czecho-Slovakia and Yugo-Slavia there is little reason why her necessary raw material should not be obtained and her situation improved. Actually the racial feelings and national jealousies which existed long before the war have resulted in the neighbours of Austria doing all in their power to render themselves independent of her. Much of the prosperity of Vienna in pre-war days rested on her merchandising, her banking and her position as the economic and artistic centre of a large Empire. Much of the activity which these factors represent is now withdrawn to new capitals, or is extinct.

In many respects Austria as an economic unit has considerable resemblance to the United Kingdom, an even more to Switzerland. She is an example of a highly-organised country unable to supply herself completely with food and lacking raw material for export. Any prosperity she may attain to must lie in the export of manufactured goods and in trading. Her condition differs from that of this country in that she has nothing to correspond to our export coal trade, but in this respect the history of the last twelve months has unfortunately brought the two countries more nearly into line. Austria is of interest to us, as any potential market is of interest, but this parallel we have suggested should make its conditions especially worthy of study. The parallel must not be pushed too far, and Austria has, of course, no Colonies or external connections. In this, however, it does not differ from Switzerland, whose record shows that it is quite possible for a country situated as Austria is to become and remain prosperous.

As Austria is a manufacturing country the absence of coal is a serious matter. This is especially true in connection with development of the valuable iron ore deposits in the Erzberg, Styria. For general power purposes no relief is afforded by oil as the oilfields of Galicia which belonged to the former Empire are now part of Poland, and Austria must import all the liquid fuel it requires. These conditions naturally turn attention to water power, of which it is estimated that 2,250,000 h.p. is available in the Alpine districts of Austria and on the Danube. Only 9 per cent. of this power has been developed as compared with 22 per cent. in Switzerland of about the same available power. Efforts have been made during the last two years to induce American, British and other foreign capitalists to assist in the development of water power in the country, but so far without success. The depreciation of the currency makes the matter one of great difficulty, but we trust the proposals will not be lost sight of in this country. Several of our large engineering concerns have recently taken steps to obtain a footing in the water power work of the world. This is very satisfactory, as there is no reason why this country should permanently remain outside one of the great engineering developments of modern times and very many reasons why it should not. Austria would be a very difficult country in which to make a start from a financial point of view, but it certainly has the advantage that any country which is prepared to assist is likely to be met as liberally as possible and to get the orders.

Hope for improvement in the economic condition of Austria is now centred on the League of Nations, which has taken up the Austrian problem as its first economic task. The matter is of great interest to us since although Austria has not in the past been one of our most important markets, we did a valuable trade with her. The rehabilitation of Austria is also of great importance as a link in the re-settlement of the Near East. She has been a great trading and banking country and recovery of her position in these respects would be to the general good. In such external trade as Austria has been able to do in the last year or so, Great Britain has unfortunately obtained a very small share, but Mr. Phillpotts states that particularly in the early months of this year we supplied cotton yarns and cotton and woollen piece goods to Austria in considerable quantities. We have also supplied men's outfitting goods, raw rubber, motor tyres, leather, pig-iron, ferro-manganese, tin, nickel and various chemical products. From Austria we have received cherrywood sticks for pipes, burnt magnesite, hats, toys, fancy goods of leather, furniture, hollow glass, automobiles and pianos. Full details of Austria's foreign trade in 1920 with much other useful information are contained in the report by Mr. Phillpotts, from which we have quoted. It is entitled "Report on the Industrial and Commercial Situation in Austria," and forms one of the valuable reports which are being published by the Department of Overseas Trade. These publications should be in the hands of all manufacturers and merchants who are interested in the various countries with which they deal.

GROUND WATER—HYDROLOGY.

The source of all water, whether direct from rivers or streams, stored in reservoirs, or obtained from wells, is rain. A knowledge, therefore, of its character, seasons and of the effects produced by it, is of primary importance to the engineer whose duty is to design, execute, improve or maintain those works constructed, or undertaken for the conservation and supply of water.

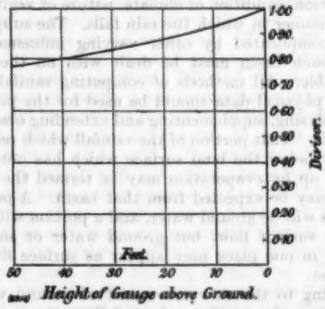
The circulation of the atmosphere is primarily caused by the air between the tropics, especially over the equator, being always heated by strong solar radiation, forming what may be called the great boiler of the motive power for the whole system of circulation; causing the air at the equator to expand and rise through the surrounding air, and from whence it is carried as an upper current towards the poles; its place being taken and filled by other currents flowing at a lower level from the poles towards the equator. The masses of air thus carried in opposite directions polewards and towards the equator in the upper and lower currents of the atmosphere tend to balance each other at the Horse latitudes about 30 deg. north and south of the equator, causing areas of high pressure in these regions, which give rise to surface winds on the earth flowing from these areas of high pressure towards the poles and the equator. The rotation of the earth affects the direction of these currents, causing the south-west winds towards the north polar regions, the north-east and south-east trades towards the equator, and the "Brave West Winds," as they are called, towards the south polar regions. The great variation of temperature of the continents compared with the ocean modify and deflect the general direction of these currents in different parts of the world, producing the monsoons. The atmosphere derives its moisture and vapour by evaporation from the surface of the ocean, principally within the tropical regions; due to the equator seeking currents of air, which are hot with but little cloud, causing great evaporation from the warm sea surface. The amount of rain varies considerably in different parts of the world, and is dependent on the direction of the moisture-laden sea winds. In all places not reached by these winds, or wherever high ranges of mountains cut off the rain-bearing winds, the rainfall is slight and evaporation predominates. In parts of Africa the rainfall is almost nil, while in parts of Assam the rainfall averages to 500 in. a year. The rainfall also varies within the limits of a single river basin. The rainfall on land areas is dependent in its distribution on the direction of the rain-bearing winds and the configuration of the land surface. Even on the coast where the prevailing wind is off shore, there may be scarcely any rain, as on the West Coast of Tropical America, Mountain ranges in any country considerably affect the distribution of rainfall: resulting from the condensation of aqueous vapour due to the cooling of masses of moist air driven up a mountain range by the prevailing winds. The area of maximum rainfall being at the mean cloud level on the wind board slope of the range, above this limit the latent heat liberated by condensation raises the temperature above the dew-point, resulting in a decreased rainfall. After crossing the mountain ranges the descending mass of air contracts in volume, then by raising the temperature rapidly above dew-point, and results in a marked decrease of precipitation. India affords such an example, the hot stratum of aqueous vapour brought by the

south-west monsoon is dashed against the precipitous face of the Himalayas, the greater part is condensed into rain on the southern slopes, a comparatively small amount is deposited on the table land of Thibet and practically no rain reaches the Gobi. In the same manner, while the great central plains of Spain are during summer parched with drought, the seaward face of the mountains that skirt the Bay of Biscay are rarely in want of rain. In the British Isles the Gulf Stream plays an important part in supplying vapour to the atmosphere, and in charging the winds with moisture. Along the western shore the annual rainfall is from 40 in. to 50 in. and in many districts from 50 in. to 75 in., that of the south coast is from 30 in. to 40 in., while on the east coast the rainfall is less than 25 in. An attentive study of a rainfall map of the world, with those of winds and configuration of land surface, will show reasons for the local distribution of rainfall in all parts of the world.

The amount of rainfall generally increases as we ascend the slope of a mountain, up to a certain limit. It has been calculated that half the vapour in the atmosphere is contained in the lowest 6,000 ft., and that at a height of 20,000 ft. there is only one-tenth of the moisture that exists near the surface of the earth; so that at extreme elevations there must be a diminution of rainfall. The point of maximum rainfall on a mountain slope depends, therefore, on the mean height of the plane of condensation, or mean cloud level, which may be ascertained from prevailing meteorological conditions obtaining at a locality. The slope of the hills also influence the height of maximum rainfall. A very precipitous elevation may result in a decrease of rainfall notwithstanding that, other things being equal, the rainfall increases as we ascend a mountain slope. In India the elevation of the line of maximum rainfall appears to be about 4,500 ft. above sea level. Mr. H. Lee, writing on conditions obtaining in America, states that above 5,000 ft. level the precipitation decreases with increase in altitude. (Proceedings, Am. Society of Civil Engineers, Vol. lxxvii.) The statement that rainfall increases with altitude is generally true—a rain cloud as it rises expands and cools, tending to precipitation; but where the windward sides of the mountain slopes are steep, until the clouds rise above these slopes there is a tendency to compression, which may reduce or prevent precipitation until the crest is reached, when a sudden fall of pressure occurs. In high mountain ranges the rain clouds become entangled among the ridges, and part with a greater part of their moisture, becoming thus exhausted before the summit is reached. But in ranges of moderate height, precipitation is prevented or retarded until the summit is reached; and the leeward side of the range may receive more rain than the windward slope. As an example, the mountain range of the Western Ghats, which runs parallel to and from 30 miles to 60 miles from the Bombay Coast, forming the western boundary of the Deccan, rises precipitously from the coastal plains to a height of from 2,000 ft. to 3,000 ft. above the level of the sea. The steep hill sides on the windward slope of the range are comparatively bare of trees and scrub, and receive but a small portion of the south-west monsoon rains, while at the crest the rainfall is great, and continues heavy down the lee slopes, the intensity diminishing as the monsoon proceeds inland.

Rainfall is represented on maps by lines of equal precipitation termed "Isohyets." These represent actual figures without reduction for elevation or other local conditions, so that a rainfall map can be studied as a direct record of actual facts. The rainfall maps for the separate months show the intimate relation between rainfall and the direction of wind taken in conjunction with the configuration of the land. The practical value of exact statistics of rainfall is greater than that of any other climatogical condition; for the water supply and fertility of the land depend in every case on the rain that falls either locally or on the heights of the water sheds. India owes a great part of its fertility to the Himalayan range, which stops and holds the vapour blown from the sea, and gives it back in rain and fertilising streams, while beyond lie the Steppes of Asia dry and unprofitable. The mountain chain on the West Coast of Southern India plays an important part in the distribution of rain over Southern India. It arrests the rain-carrying winds of the south-west monsoon and deprives the country lying to the lee of it of a sufficient rainfall. The uncertain character of the rain is so excessive that the agricultural out turn so far as it depends on the rainfall of the year varies considerably. Two tracts may be excluded as secure. The areas of constant rainfall, and the areas of constant drought, because in the latter no crop is raised without resort to artificial irrigation, as in Sind, Western Rajputana, and Western Punjab. The areas of constant moisture are Eastern Bengal, Assam, Central Provinces, and the strip of land west of the Western Ghats along the Arabian Sea. Between insecure tracts which in nine years out of ten get enough rain to tempt a large population to grow crops without irrigation, and in the tenth year are afflicted with complete drought, to the absolute certainty of produce, there are various grades of suffering. The area of uncertain rainfall runs from Lahore to Allahabad, across to Ajmir, round by Udipore to Baroda, and finally through Bombay Deccan to Mysore. The most perilous districts lie under the lee of the Western Ghats.

Measurement of Rainfall.—The amount of rainfall in any given shower at any locality is measured by the depth of the pool of water in inches which would be formed if the ground was perfectly horizontal, and none of it soaked in, or evaporated, or flowed away. The instrument employed for determining the amount of rainfall is called a rain gauge. On an emergency a rain gauge can be made out of a biscuit tin, or any vessel with vertical sides, and an unobstructed mouth. Such a vessel standing level would collect the rain, the depth of which could be measured by an ordinary inch rule. It is rare to find rain so heavy so as to give any appreciable depth, and in order to estimate the amount of rainfall to small fractions of an inch, the device is employed of measuring the water collected in the receiver of the gauge in a glass jar or tube of smaller diameter than the mouth of the collecting funnel. Thus if the funnel exposes a surface of 50 sq. in. and the measuring glass has a cross-sectional area of 1 sq. in., the fall of $\frac{1}{50}$ of an inch of rain on the funnel will give a quantity of water sufficient to fill the measuring glass to a depth of 1 in. In order to get good and trustworthy observations, it is necessary to have good instruments and conscientious observers. The smallest diameter for a serviceable rain gauge is 5 in., and is the size generally used. Trials with gauges of various diameter ranging from 1 in. to 2 ft. have shown that if they are set perfectly level, and observed with great care, exactly the same rainfall has been registered by all of them. The standard height rain gauges are fixed above ground is 1 ft. The higher a gauge is fixed above the ground the smaller is the quantity of rain caught



owing to the eddies carried by the wind about any prominent upstanding object. The annexed curve diagram, due to Beadmor's Hydrology, gives the divisor to be used for increasing the quantity of rain observed at any given height above ground level, so as to make the observation equal to that at ground level. It is more important, however, to have rain gauges placed at a uniform height above the ground than to have them of uniform diameter. The India Meteorological Department use a "Segmous" rain gauge; the funnel being provided with a brass rim which should be truly circular and exactly 5 in. in diameter.

Rain gauges should be set in open situations away from trees, walls, and buildings, at the very least as many feet from their base as they are in height, and should be so firmly fixed that they cannot be blown over. The gauge is either planted in the earth and fixed by stakes, or placed in a hole, which exactly fits it, in a block of concrete. The top of the rim should be 1 ft. above the ground, and, as already stated, must be truly level. The Snowdon pattern rain gauge has a 6-in. cylinder on top of the funnel, and a sharp brass rim. There are several patterns of self-recording rain gauges, such as Beckley's, Halliwell's, Casella's, and Negretti and Zambra's, which give excellent results in careful hands. The two principal types of self-recording rain gauges are the float pattern and the tipping bucket pattern. In the former the rain is collected in a reservoir in which there is a float carrying a pen which marks a trace on a chart, showing the rate at which the rain fell. In the tipping bucket pattern the rain is collected in a small tilting bucket divided into two equal parts which tip over alternately when 00·1 in. has fallen. A lever carrying a pen is thus raised, which traces a series of steps on a chart. Rain gauges are generally read at 9 a.m. mean civil time of the locality; and record the rainfall for the past 24 hours. In India rain gauges are read at 8 a.m. It cannot be too strongly impressed on observers that they must be strictly punctual to the hours of observation. Rainfall registers are important records, and should be abstracted and carefully preserved. In the case of projects for a water supply it is always desirable that the rainfall on the catchment basin should be ascertained as far as possible by direct observation on the ground itself; and the selection of the sites for the rain gauges should receive careful consideration. Unqualified reliance on a single gauge in a drainage area is objectionable and might cause serious errors in estimating the yield to be expected, whether from ground water, or from direct flow; owing to the variations produced by irregular surface. The very small area of a single gauge is also subject to much greater variations in shorter periods than can possibly occur over large areas. For a single mountain valley, Dr. Deacon suggests five rain gauges; three in the axis of the valley, of which one is near the junction of that axis with the boundary of the water shed, one gauge on each slope about the middle height, and approximately in a line perpendicular to the axis of the valley passing through the central gauge. Each gauge should have 10 yards to 15 yards around it of an uninterrupted plain representing the general level or inclination of the ground for a much larger distance beyond. The arithmetical mean of the four gauges which may be checked by the central gauge will give the mean rainfall on the area. The Tank Restoration Party of the Madras Irrigation Department assumed a standard area of 5 sq. miles, as so many of the irrigation tanks had drainages of about that area connected with them, and it was considered that by its adoption the risk of error from under-estimating the rainfall in dealing with the generality of works would be avoided; and, secondly, that it was extremely probable that a maximum rainfall might extend over an area of this size. D. Mill states that the only way by which a fair estimate of the total rainfall on a catchment area can be obtained is by constructing a map showing not only the readings of the gauges on the ground but also those at all available surrounding stations, to a distance of many miles. He considers that while there is undoubtedly local variation of average rainfall, the records are all in harmony with the general principles of the relation of rainfall to the land and prevailing winds; and a knowledge of the general distribution of rainfall over a wide stretch of country is an immense help in deciding on that of any small area within it (Proceedings, Institute of Civil Engineers, vol. cxciv).

Among all phenomena of Nature, rainfall is the most variable. In some cases the variation is very considerable, the maximum annual rainfall being very much in excess of the minimum, but the worst feature of the variation is that there will sometimes

occur several consecutive dry years. At places, however, where the average rainfall is large the extremes of both wetness and of dryness will be less pronounced than at those where the usual rainfall is small. In order to obtain the mean annual rainfall of any place or at any station, it is necessary that the observations should extend over a long period of time, owing to the wide range of the irregular variations, and the rare occurrence of the extreme values. A period of thirty years is the shortest time that may be profitably considered. The average or mean of fifty to sixty years' observations would give substantially better results. Dr. H. R. Mill, director of the British Rainfall Organisation, however, considers it important to work with one and the same period for all stations. ("Distribution of Rainfall over the British Isles," Proceedings of the I.C.E., vol. clv.) Sir Alexander Binnie considered the true mean to lie between the period of thirty-three and thirty-five years. From 14 stations scattered over the world he arrived at the following results :—

1. The percentage of years, in which the rainfall is above the mean rainfall, is 45·8.
2. The percentage of years, in which the rainfall is below the mean rainfall, is 54·2.
3. The average fall of wet years is 1·19 of the mean rainfall.
4. The average fall of dry years is 0·83 of the mean rainfall.
5. The average fall of the three consecutive dry years is 0·76 of the mean rainfall.
6. The maximum rainfall is 1·52 of the mean.
7. The minimum rainfall is 0·59 of the mean.
8. The proportional number of periods of three consecutive dry years in 100 years is 20·3.

Sir Alexander's ratios do not appear to be applicable to Continental climates where the rainfall is comparatively scanty. The variation of ratios between maximum, mimimum and mean rainfall are marked even in Peninsula India, as will be observed from the statement below. The rainfall is that registered from 1870 to 1917.

Station.	Mean.	Maximum.	Minimum.	Mean of Lowest Three Consecutive Years.
East Coast—				
Gopalpore ..	42·87	78·68	26·63	31·26
Coconada ..	39·80	78·92	16·06	28·35
Madras ..	49·02	78·72	21·60	33·49
Negapatam ..	53·07	85·79	23·76	40·20
West Coast—				
Cochin ..	113·81	101·59	84·51	95·39
Calicut ..	118·57	165·77	74·30	107·40
Mangalon ..	131·00	182·20	89·36	114·00
Ceded Districts—				
Bellary ..	19·00	35·02	7·23	13·09
Adoni	26·28	53·31	11·25	19·37
Anantapur ..	20·29	37·12	3·90	14·52
Cuddapah ..	32·01	58·50	9·46	19·99
Carnatic—				
Trichinopoly ..	32·83	43·11	20·14	26·72
Tanjore ..	36·02	49·01	20·65	24·01
Madura ..	34·93	54·04	16·16	25·51

Mr. Thomas William Keele, from observations of rainfall in Australia, the British Isles and other places, and also of the records maintained in Egypt of the Nile floods from A.D. 640 to A.D. 1451, considers that the period of a weather cycle is seventy-six years ("Investigation of Nile River Flood Records," Proc.I.C.E., vol. cciii). The Hindus have a cycle of sixty years, the result possibly of centuries of observation, each year bearing a name which indicates, among other events as likely to happen, the agricultural season and so indirectly the rainfall of the year.

Writing on the variability of rainfall in India, Mr. Blandford states that the degree in which the rainfall of any given year is liable to deviate from the mean is proportionally greatest in the driest part of the country. That is, the more copious the rainfall of any locality is, the less the variations are these from the mean. From observations of twenty-two years, in no single year has the rainfall been either deficient or excessive over the whole of India, an excess in one part of India corresponding to a deficiency in another part. On an average two-thirds of India varies in one way and one-third in its opposite. But in 1864, 1868 and 1873 the rainfall was deficient, and in 1878 excessive, over a very much larger proportional area. Taking the average rainfall of India as 42 in., the greatest deficiency during twenty-two years preceding 1889 was about 6·6 in. in 1868; and the greatest excess 6·6 in. in 1878. A serious drought in Peninsula India is followed by one in Northern India the next year. The excessive falls of rain are the result of long-lived cyclonic storms in which the barometer is not greatly depressed; such excessive falls frequently occur in years of partial drought, as if in such seasons the whole energy of rain formation were concentrated in the storms to the deprivation of parts of the country not reached by them. Thus in 1875, although in the Punjaub it was one of the wettest years on record, the rainfall was very deficient in Bengal and the southern half of the Peninsula ("Indian Meteorological Memoirs, vol. iii, Rainfall of India"). It is interesting to note that the year 1878 given by Mr. Blandford as the year of the greatest excess of rainfall for the whole of India corresponds to the year "*Bohu daniya*," or year of abundance of grain in the Hindu Cycle mentioned above.

Of the rain that falls upon the earth a portion returns to the atmosphere, a portion soaks into the earth, reappearing as vegetation or remaining below as ground water; another portion remains on the surface in streams, rivers, ponds and lakes. A knowledge of the phenomena that pertain to these changes in condition and of the physical and chemical properties of the water itself constitutes the science of Hydrology. Every feature of this science is of direct value in the economic development of a country. Temperature affects evaporation and rainfall, and thereby affects the total yield of a hydrographic basin. Low temperatures exerts a further effect mainly on distribution of flow by forming ice and snow and temporarily storing the precipitated moisture. The geological character of a basin also affects the yield. Large areas and depth of sand form the best natural reservoirs. On the other hand if the basin consists of bare, impervious and unfissured rock, it is evident that the whole rainfall discharged on it, less the amount evaporated, will flow off the ground and thus be lost unless collected and stored. Where the vegetation is dense, and the basin is flat, or is wooded, or covered with forest and undergrowth, the rainfall is retained and allowed to pass off slowly. Their protection against evaporation makes forests and woods the guardians of streams; the uneven forest floor and its spongelike qualities stop the rapid and ruinous draining of surfaces with its attendant denudation, and favour slow percolation and a steady supply to springs.

Peat bogs have also the same effect in this spongelike action. The yield or supply of water that may be expected from any hydrographic basin either from direct flow or from water that has percolated to and reached the saturated ground water plane is thus affected by its geological structure, configuration, condition of climate, nature of vegitation and manner in which the rain falls. The subject is also complicated by other varying influences, so that each basin must be dealt with on the data available. All methods of computing rainfall and other physical data should be used for the purpose of analysing, supplementing and extending observed records. That portion of the rainfall which remains on, or below the land surface which has not been taken up by evaporation may be termed the yield that may be expected from that basin. A portion of this will be ground water, and a portion will pass off as surface flow, but ground water or sub-soil water in one place may appear as surface flow in another.

Owing to the slow movement of ground water, the seasonal variations of rainfall are to a certain degree equalised, and the ground flow for any hydrographic basin is fairly constant, and in a great measure controls the low water surface flow off that basin. The freshest in the basin stream are due to the variation of, and the manner in which, the rain falls on the basin. The yield that may be expected from the basin from both surface flow and ground flow, will be the rainfall on the basin less losses. These losses are :—

(*a*) Evaporation from water surfaces in the basin.
(*b*) Evaporation from soil.
(*c*) Transpiration by vegetation according to the seasons and temperature.

The power of air to carry off moisture is very considerable; the Mediterranean Sea affords an example of the considerable amount of evaporation from water surfaces, for notwithstanding the rivers flowing into it, the accession to its waters does not keep pace with the evaporation from its surface, as notwithstanding the occasional outward current there is almost a constant inset of current into it through the Dardanelles and the Straights of Gibraltar. The Dead Sea with the River Jordan flowing into it is kept by evaporation at its level of 1,300 ft. below the level of the Mediterranean. In the case of a liquid exposed to air and at atmospheric temperature, the rapidity of evaporation increases with the extent of the surface, the dryness of air, and the rapidity of renewal of the air immediately above the surface. Evaporation from large surfaces of water are less, owing to the greater humidity over the surface, than from small pans or evaporometers. Mr. Palmer states that, from elaborate records of evaporation from 1871 to 1887 in Rajahputana, if the evaporation from a tank not more than 4 ft. in depth as an average be taken as 1: then that from an evaporometer in a low and somewhat sheltered locality was 1·15 and from an instrument in an open and wind-swept spot 1·41. Had the tank been deeper the ratios would have been still more in its favour (Proc.I.C.E., vol. cxciv, page 128). The statement below shows the evaporation from a circular pan of some 3 ft. diameter floating in the Red Hills Reservoir, situated 8 miles east of Madras, which in addition to irrigating about 1,000 acres of paddy land, supplies the City of Madras with potable water. The mean temperature and relative humidity are those observed at Madras. The climatic conditions at Red Hills are probably drier.

1	2	3	4	5	6
Month.	Evaporated from Water.	Mean Temperature F. at Madras.	Relative Humidity per Cent. at Madras.	Rainfall at Red Hills.	Remarks.
1914.	in.			in.	
October ..	2·35	80·4	84	22·06	Evaporation for 17 days.
November ..	3·4	78·4	82	8·51	Evaporation for 22 days.
December ..	4·0	77·1	76	0·31	Evaporation for 27 days.
1915.					
January ..	3·37	76·3	80	5·96*	* Unusual rainfall for January.
February ..	4·35	78·5	77	0·53	
March ..	6·30	81·8	77	0·00	
April ..	7·60	84·7	76	0·06	
May	9·00	89·6	65	0·21	
June ..	6·60	88·2	67	1·45	
July ..	5·85	84·7	74	7·78	† Evaporation from October 1 to 10. Instrument sent for repair.
August ..	7·35	85·4	72	1·76	
September ..	8·05	83·8	76	3·31	
October ..	2·30†	83·5	78	2·64	
November ..	—	79·1	85	19·55	‡ Evaporation for 10 days, December 22 to 31.
December ..	1·4‡	76·3	74	1·02	

Assuming the evaporation constant for the month :—

Evaporation—	in.
October, 1914	4·28
November, 1914	4·64
December, 1914	4·60
October, 1915	6·5
November, 1915	No record.
December, 1915	4·34

Assuming the evaporation in November, 1915, equal to that of November, 1914.

Total evaporation and flow, Red Hill Lake, for 1915 = 73·955 in.

Rainfall at Red Hills, 1915 = 43·88 in.

Mean relative humidity for 1915 at Madras = 75·1 per cent.

Mean temperature for 1915 at Madras = 82·66 deg. F.

The annual evaporation from water surfaces in the interior of New South Wales is about 84 in. At Coolgardie the evaporation was 85 in. in 1905. Evaporation records in Egypt show for mean temperature dry bulb 90·50 deg. F.; per cent. of humidity, 20; rainfall, nil; evaporation = 1·32 ft. per month.

Dr. Walter Leather gives the following formula for estimating evaporation from water surfaces :—

E = Evaporation in millimetres for 24 hours.
D = Dryness = 100 − (Humidity at 8 a.m.).
W = Mean wind velocity for the 24 hours in miles per hour.
T = Mean temperature in degrees F for the 24 hours.

$$E = 2{\cdot}0\ (\log t - 1{\cdot}74) + 0{\cdot}33\ (\log D - 1{\cdot}00) + 0{\cdot}36\ (\log W - 0{\cdot}125).$$

The evaporation from soil and losses due to transpiration have already been dealt with under "Wells and Ground Water" (ENGINEERING, vol. cx, page 727). Mr. Meyer (Proceedings Am. Society of Civil Engineers, vol. lxxix, 1915, page 1081), gives curves of evaporation from land surfaces for various temperatures and rainfalls.

To the values so given, a coefficient varying from 0·95 to 1·25 must be applied, depending on vegetation, topography, character of soil, humidity and wind. The losses or gain to the ground water of a locality will depend on the variation of the rainfall on the locality, and the total loss or gain for any period of years may be estimated from a residual mass curve of the annual rainfalls on the locality. Another loss requires consideration. In countries, more particularly in the tropics, where rain falls only in certain periods of the year, and the rate of fall is consequently heavier than in countries where the rainfall is more uniformly distributed throughout the year, the rain is less penetrating in proportion to its quantity, and instead of feeding springs and streams and nourishing an absorbent cushion of green herbage, the greater part flows off the surface into the dry beds of its water courses, causing temporary torrents. Mr. H. F. Blandford, in his book entitled "Climate and Weather of India," says: "In uncultivated tracts where fires have destroyed and withered the grass and bushy undergrowth, and have laid bare the soil and hardened its surface, this action is greatly enhanced; and while all perennial water supplies which depend on the absorbed rain are either greatly reduced or altogether suppressed, a rainfall which, if husbanded by Nature and art, would suffice for agricultural and domestic requirements of the population is thrown into water courses and rivers, and not only is wasted, and lost for any useful purpose, but by producing floods becomes an agent of destruction. Much more, therefore, than in temperate regions is it incumbent on us to safeguard such provident arrangements as Nature has furnished for the purpose."

NOTES.

An Engineering Dispute.

An engineering case of some interest was decided at Lambeth County Court on Monday, the 8th inst. The plaintiffs, the Electrical Apparatus Company, Limited, of Vauxhall, had bought a new power press from certain manufacturers, and when they had used it intermittently for about three months it broke through the main frame at the flywheel bearing, when engaged in the flattening of small pieces of brass. The manufacturers, the defendants, offered to repair the machine by welding the broken part, but declined to replace the fractured casting with a sound new one. The buyers did not consider that this would be satisfactory, and, after some correspondence, sued the defendants for the return of the purchase price, a sum of about 97*l*. The defendants contended that the machine must have been improperly used and subjected to too great a strain. The plaintiffs' evidence was to the effect that that had not occurred, but that the fractured part showed that there had originally been some welding at that part before the machine was delivered to them, and that the fracture was due to a resulting local change in strength. Judge Parry held that this was the explanation of the fracture, and that in respect of the welding in the frame the machine when sold and delivered was not up to the proper standard of fitness or quality, and he gave judgment in favour of the plaintiffs for the amount of the price, which they had paid, and costs.

The Export of Electric Energy from Norway.

After protracted negotiations, an important conference for the furtherance of a plan for the export of electric energy from Norway to Sweden and Denmark will be held at Christiania on the 19th and 20th inst., and it is expected that actual work upon the scheme will be begun within the near future. The waterfalls which can be most advantageously exploited in connection with the proposals are those situated west of the Firth of Christiania, from which it is estimated that some 1,500,000 h.p. should be available. It is calculated that about 200,000 kw. are already being generated in Eastern Norway, in Denmark and in the part of Sweden concerned and, assuming considerable development in the domestic load, it is estimated that the total consumption should reach 1,000,000 kw. The transmission lines would pass through districts inhabited by 5,000,000 people. It is estimated that this Norwegian energy could be supplied in Sweden more cheaply than it could be generated at home. The development, if it proceeds, would probably be carried through in stages of 100,000 kw. at a time. A beginning would probably be made with the Eidfjord Falls, where all preliminary work has been done. The cost of the installation at these falls with transmission lines to the Swedish frontier would be 102,000,000 kroner (5,600,000*l*.). For the Danish supply alternative lines of transmission have been considered, *via* Goteborg across the Cattegat to Fredrikshavn and from the south of Norway to Hirtshals, but we note that the Commercial Secretary of H.M. Legation at Copenhagen is of opinion that the economic situation in Denmark will prevent any such scheme from being carried out for some time.

Permanency of Inks.

It is well known that considerable trouble has been caused lately through the fading of the inks employed on the licences which now have to be carried on motor road vehicles, and it is instructive to note that some years ago in a different connection similar trouble was caused in the United States of America. This was in connection with official records, more particularly for patent purposes, and tests were applied to the inks apparently not only in that department but in other executive departments. A case was argued before the acting Commissioner of Patents, and it is reported in the *Official Gazette* of the United States Patent Office, Vol. 84, page 1,732. The examiner had refused to enter a typewritten amendment on the ground that it was written in fugitive ink. The attorney for the applicant urged the acceptance of the amendment because he stated he purchased the ink as non-fugitive and had used it in writing papers which were subsequently accepted by the Patent Office without objection. It appeared, however, that according to the examiner the question of the use of fugitive inks had become important and scarcely a day passed but objection on this ground had to be raised in connection with papers filed as part of a permanent record of applications for patents. The examiner submitted a statement of the tests applied to determine the permanency of ink, it being understood that these tests were those commonly employed by other executive departments to the same end. The tests are two in number—first, the application of the well-known Labarraque's solution, followed by a saturated solution of oxalic acid, to determine whether the ink will be faded by the action of light or chemicals, and, second, the application of a 10 per cent. solution of nitric acid. The examiner states that an ink which will not stand the latter test will rapidly fade, and is absolutely unsuitable for public records. Inks which have a foundation of lamp-black or carbon are not materially affected by these tests, the carbon remaining even when colouring matter used with the ink is removed. The tests were applied to the particular documents in question and it appeared that the writing was thereby not only rendered illegible, but practically obliterated.

A Question of Income Tax.

The Court of Appeal recently decided a case (F. L. Smidth and Co. *versus* Greenwood), on the vexed question of what constitutes the exercise of a trade in the United Kingdom, within the meaning of the Income Tax Statutes. The parties concerned were Messrs. F. L. Smidth and Co., a Danish firm who carry on in Copenhagen the business of manufacturing machinery for cement works, brick works, mortar works, and mining industries, and ship such machinery to manufacturers all over the world. The two partners of the firm are Danish subjects, and reside in Copenhagen. The firm have, or had during the period in question in the case, an office in Westminster, which was in charge of a consulting engineer, Mr. S. G. Robinson, who was a whole-time employee of the firm. Mr. Robinson was in the habit of receiving inquiries for machinery such as the firm could supply and sending on to the firm the particulars of what was required; and when the machinery was supplied he was available to give the English purchasers the benefit of his experience in erecting it; but the contracts between the firm and their customers were made in Copenhagen and the goods were shipped "f.o.b." Under these circumstances the Commissioners of Income Tax held that the firm exercised their trade within the United Kingdom and were therefore liable for income tax. On appeal, Mr. Justice Rowlatt held that the place where a trade was exercised was the place where the transactions forming the business were closed—in the case of a selling business by the selling of a commodity and the realisation of the profits; and that the firm's trade was exercised in Denmark and not in the United Kingdom. The Court of Appeal took the same view. Lord Justice Atkin said that a manufacturer of machinery exercises his trade by making the machinery and selling it again with a view to profit, and that the part played by Mr. Robinson in receiving inquiries, advising prospective purchasers, and supervising the erection of the machinery did not in the whole circumstances of the case amount to the exercise by the firm of their trade in the United Kingdom. A subsidiary question in the case was whether a certain section of the Finance (No. 2) Act of 1915 had the effect of rendering the firm liable to income tax, but the court took the view that it related merely to the method of making assessments and did not impose any new liability on foreign firms.

Carbon Monoxide Poisoning.

The Memorandum on "Carbon Monoxide Poisoning," which the Chief Inspector of Factories issued last week, should be welcomed as a timely warning, though it may be received with shrugging of the shoulders by certain classes. Everybody knows that gas companies would like to be absolutely unrestricted as to the percentage of carbon monoxide in the gas they send into the mains, and that they point to the non-increase of accidents in their own works since the substitution of carburetted water gas, containing more than 30 per cent. of CO, for straight coal gas, with about 9 per cent. of CO, as a proof that, with proper care, a high CO gas is not more dangerous than ordinary gas. The question should not lightly be discussed, however. The recent inquiry of the Carbon Monoxide Committee, the report of which is soon to be published, made it clear that in forming an opinion as to the dangers of CO even medical men rely largely upon experimental researches of the past century, and that they are not agreed as to cumulative effects. Moreover, it appears that some recent statistics cannot be accepted as complete and quite reliable; conditions were admittedly abnormal in some war works. The factory inspectors certainly take a serious view of the dangers of CO, and their opinion is entitled to full respect. In the period 1908 to 1912 producer gas and blast-furnace gas caused 119 (11) and 110 (17) accidents, the numbers in brackets indicating fatal cases, while gases from coke ovens, lime kilns and braziers, &c., and from coal gas were responsible for 28 (7) and 59 (5) cases—a total of 316 (40) cases for the period. For the period 1913 to 1919 the corresponding figures were: 114 (12), 112 (24), 77 (10) and 56 (13)—total, 359 (59) cases. Thus the fatality percentage had certainly increased in the latter period, when the CO percentage in industrial gas had risen, and this period, it should be noted, does not include the two years 1915 and 1916, for which no figures were available. The Home Office has drawn up a warning notice, to be displayed in suitable places, drawing attention to the danger, its symptoms and preventive measures. Nobody should be allowed to enter rooms where CO may have accumulated, before the rooms are flushed out by fresh air. Producer-gas installations should be in the

open or in ventilated sheds, and gas engines should not be put down in confined spaces or basements; five women were in 1919 overcome by gases leaking into a polishing shop from an engine room. The exhaust and vent pipes should not terminate in a building or under a covered way; engines should not be stopped with gas and air valves open. In gas works, as in others, many accidents have occurred in connection with cleaning and repairing. In order to avoid leakage, producer gas should not be forced through mains at a pressure of more than 2 in. of water. Open braziers, coke stoves and rivet-heaters' fires in ship's holds or tanks, are also sources of danger. In laundries, where producer gas was used for heating, up to 8·6 volumes of CO per 10,000 have been found against the maximum of 0·8 volume with coal-gas heaters; in such places a high standard of ventilation is needed. The symptoms of CO poisoning are well known, but the victim is generally rendered powerless by the gas before he can make his escape. Reliance on a folded handkerchief has cost many a would-be rescuer his life; the victim should be kept resting for at least 2 hours, and not be offered phenacetin or aspirin to cure his headache; serious attacks of heart failure have followed the administration of such drugs in gas poisoning. Attention is drawn to the gas mask of Dr. L. Levy, a respirator canister in which CO is catalytically oxidised by the oxygen of the air. That respirator might obviously fail, as is pointed out, when the air is deficient in oxygen, as it would be in blast-furnace gas.

LITERATURE.

Meteorology: An Introductory Treatise. By A. E. M. Geddes, O.B.E., M.A., D.Sc., Lecturer in Natural Philosophy in the University of Aberdeen. London: Blackie and Sons, Limited. [Price 21*s.*]

In many high schools nature study finds a conspicuous place in the curriculum, and the variations of rainfall, of temperature, of climate generally are the subject of systematic and careful observation. Such practice will always be of educational service to the individual, but if it is to be of permanent value to the community it must be pursued with knowledge and discretion. This treatise should be welcomed wherever such enlightened study is displayed, for the assistance it affords in the collection and utilisation of data, and the training in regular and continuous observation that will follow the adoption of the methods indicated. Judging from several elementary treatises that have appeared in recent years, it would seem that meteorology has not been treated with the rigour that the importance of the subject deserves. Unscientific looseness may sometimes be detected, and there is little attempt to render available, or to apply, the rigorous deductions of physics or thermodynamics. Description occupies too large a share in the plan and reasoning and correlation of results too little. Dr. Geddes preserves a happy medium.

The ever-changing phenomena with which meteorology busies itself afford a great inducement to record lavish observation, without any definite idea whither such industry is leading. Many a man enjoys a scientific reputation among his neighbours because he reads a rain-gauge with accuracy and regularity, and it would be cruel to suggest that he effects little more than an automaton; but there is a stage, be it remembered, when the observer degenerates into a machine. An observation made without a definite scientific object in view is a useless observation, and one that may prove a hindrance rather than a benefit. The accumulation of disconnected facts cumbers the scientific ground and hampers the efforts of those who would extract some useful result. It is one of the merits of the book before us, that it demonstrates that the memorable advances made in meteorology in recent years have not followed from the discussion of purely observational material, but have been derived from the results of physical science pursued with quite different objects, or by special investigations as in the use of kites and balloon experiments in the upper air. Theoretical deductions have been fruitful, but apart from climatology, the ordinary meteorological observations have achieved singularly little. The cardinal advances that have been recorded have hinged upon Buchan's demonstration of the relation of wind velocity to barometric gradient, and the utilisation of gradient velocities by Sir Napier Shaw; upon the use of kites and *ballons sondes* which supplied De Bort and Hildebrandson with the material for deriving a new solution of the problem of the circulation of the atmosphere; upon the work of the bolometer in the hands of Langley and Abbot which has given a trustworthy value of the solar constant, and such epoch-making advances. On the other hand, where surface observations of temperature, moisture, and wind velocities might have been expected to have taught us much concerning the movements and behaviour of cyclones, the outcome is distinctly disappointing. The work of Van Bebber, of Köppen, of Rykatcheff, and of many others, promising as it looked, has led to little progress. Similarly, long series continued through years, which have been examined in the hope of detecting a recurrence of cycles, have only succeeded in proving the hopelessness of the search.

The plan of the book generally follows conventional lines. An introductory chapter gives a useful synopsis of the history of meteorology, and indicates the methods employed in attacking and solving the class of problems, with which this science deals. Very properly are included among these methods some remarks, or propositions, on mean values and probable errors, for the discussion of meteorological data requires the evaluation of the deviations from the mean result on which the determination of the probable error depends. An example is also given of the application of Fourier's analysis, and the value of this example might have been further illustrated by exhibiting the calculation of, say, the first three harmonics. Two other chapters are included in this introduction, one giving a description of the constitution of the atmosphere, the theatre in which is displayed the phenomena subsequently discussed. In this connection, Dr. Geddes reproduces Professor Humphrey's chart showing the distribution of the gases in a vertical column extending 150 kilometres above the earth's surface, but the value of this is doubtful, for its accuracy is questionable and its acceptance as a general representation is not general. Such a diagram early introduces the student to the doubts and uncertainties that have long obstructed the road he will have to travel, and may make him distrustful of deductions. The latter of the two chapters is devoted to the subject of the sun's radiation, and it is here probably that the student will meet with his first difficulty. Practically he is told, and of course quite correctly, that the whole of the energy which is manifested in meteorological phenomena comes from the sun. It is true that the radiant energy falls upon material of different absorptive and reflective power, as land and water, but the arrangement of these materials does not vary from day to day, and from year to year must be insignificant in comparison with the extent of the earth's superficies. There remain the rhythmical effects due to the earth's rotation, the obliquity of the ecliptic and the eccentricity of the earth's orbit. These continually recurrent changes constitute the only variables in the problem, and are discussed by the author with great care and lucidity. It will be inferred that the external forces acting on the atmosphere on any one day are very similar to those on the day preceding and following. On the same day in consecutive years, the total energy absorbed by the earth, including the atmosphere, is practically identical, and yet the weather effects in a particular locality are greatly different. As already indicated, all attempts to detect a repeating cycle have proved failures; the operation of the same original amount of energy is capable of producing very different results. There is apparently a source of internal variability in the earth's atmosphere, capable of giving rise to varying phases, sufficiently powerful to mask the general solar effect and to defy quantitative analysis. Such latent operations are a puzzle to the tyro and will ever prove a stumbling-block to the long period forecaster.

The second section comprises the main subject matter of meteorology, dealing with the measurement and effect of temperature and of pressure, of the presence of water vapour in the atmosphere and the effects of wind. The phenomena depending on these factors have often been described, and their treatment admits of little originality, differing only from that in previous works in the thoroughness of handling and the incorporation of more recent results. Whether these are developed from theory or are the outcome of experiment, Dr. Geddes is intent on making them the scientific property of the community. He recognises that it is only "by clear and scientific teaching that many of the old fallacies that have held the field in this sphere, from the days of the Babylonians up to the present, can be dispelled," and he struggles ably to inspire a more intelligent conception. Among these fallacies or inconveniences are, perhaps, to be reckoned the measurement of pressure by the height of a column of mercury, and the use of the Fahrenheit scale of temperature. For the former is substituted the "millibar," and for the latter the Kelvin or absolute scale. This innovation is quite justified and in accordance with modern practice. It is undesirable that those who are entering on the study of meteorology should grow accustomed to a scale of units that they will subsequently have to discard. Since pressure is a force, it should be expressed in units of force, and such a scheme necessitates the use of the centimetre-gramme-second system. The scale of centigrade degrees measured 273 deg. below the freezing point of water is not without its convenience in avoiding negative readings, but as used here it indicates that the results of physical enquiry and of the laws of thermodynamics and of radiation will be pressed into the service of meteorology.

The chapter on the free atmosphere, though it must be classed with meteorology generally, opens a new subject of enquiry, since it enlarges the view of the observer by removing him from his position at the bottom of the ocean of air and furnishes him with new means for research. By the use of kites and balloons, carrying appropriate instruments, the present century has witnessed such a great development of the science, causing many old theories to be abandoned and the substitution of others founded on more recently acquired facts, that the study of meteorology may be said to have started afresh. The author has compressed a vast deal of information into this chapter concerning the instruments employed, the conduct of the observations, the nature of the results obtained, and the degree of reliability to be placed on the deductions. Those who have learnt their meteorology in the old school will read this chapter with pleasure and profit.

Electrical, optical, and acoustical phenomena occurring in the atmosphere form the subject of the third division, and are discussed rather apologetically "as not pertaining directly to meteorology," and in some directions, as, for example, in the section on ions the author may be travelling out of the record. The subject could either have been suppressed or extended with advantage. This is quite unimportant and in other matters he can easily vindicate himself. The chapter on lightning is valuable practically, and the interest awakened during the war in the methods of sound-ranging is not yet exhausted. There is, too, a physical distinction between water-drop clouds and ice-particle clouds, giving rise to optical phenomena, that supply information useful in weather forecasting. This latter topic, which is regarded by some as the end and object of all meteorological enquiry, is fittingly reserved for the last chapter, an arrangement that permits the reasoning and conclusions of the preceding sections to be utilised and illustrated. In this chapter, the maps are of a fair size and tell their tale well, but elsewhere, the scale is too small to be agreeable. If this is a blemish it is amply redeemed by the excellent plates of clouds and by the coloured diagrams which are both instructive and artistic. The book is calculated both to arouse interest and to satisfy it.

The Measurement of Steady and Fluctuating Temperatures. By B. Roxbs, M.Sc., A.M.I.Mech.E. London: Constable and Co., 1921. [Price 16*s.* net.]

From internal evidence, it may be concluded that this treatise is arranged to supplement and illustrate the theory detailed in a previous work of the author

on "Heat Transmission by Radiation, Conduction, and Convection." Those who wish to follow both the fundamental principles and their application in industry, will find a certain amount of inconvenience from this method of treatment, but it may be that the two works are not intended for the same class of readers. The use of pyrometers has increased to such an extent and become such an indispensable part of the equipment of many works and factories, that a sufficiently large class of readers could be found among those who are actively engaged in measuring and controlling the temperatures of furnaces, or of the molten metal they produce. This class is very well catered for in the present treatise, the instruments are described with accuracy; the illustrations enable their functions to be clearly followed; the circumstances under which each class may be appropriately used are carefully detailed and the sources of error adequately commented upon.

It is possible, however, that too much attention is given to the measuring apparatus and too little to the manner in which it is used. The correct reading of the instrument, accurate calibration, and care on the part of the observer, no doubt give a result which probably carries confidence, and rightly, but it may not be that required for the purpose in hand. For example, in the simplest case of a mercury thermometer, the height of the mercury in the stem indicates only the temperature of the mercury in the bulb, and unless this approximates very closely in temperature to that of the substance it is desired to measure, the readings are misleading, though they may be repeated with gratifying consistency. This is a source of error that is not connected with pyrometry properly so called, but arises from failure to recognise the necessity of correct installation or a want of due appreciation of interfering conditions. It is one, however, that is liable to affect all temperature measurement, and is a source of systematic errror on which the author might have insisted more urgently. In the latter chapters of the treatise, when dealing with actual measurements of temperature under conditions of great experimental difficulty, the results derived are examined with discretion and acuteness, but the same thoughtful attention is required when discussing all instrumental records. Consistent results are often preferred to accuracy.

Within the last few years very considerable advances have been made in the construction of instruments for the measurement of high temperatures, and not only has greater accuracy over a wide range been attained, but the continuity of the thermodynamic scale is better assured. It would probably be correct to say that our knowledge of the temperature scale now renders our measurements up to the limit of 1,600° C., or even to the melting point of platinum, comparable both in facility and accuracy with those made in the neighbourhood of 800° C., twenty years ago. Much higher temperatures are produced now than formerly, and the time seems ripe for the adoption of an international scale, but this project is apparently in abeyance, at least, Mr. Royds makes no mention of it in his preliminary chapter on the measurement of temperature. The improvement now noticeable can be traced to the beneficial influence of the National Physical Laboratory and of similar institutions in other countries, which by their insistence on the necessity of greater uniformity of calibration have rendered an essential service to industry. This satisfactory degree of accuracy and also of convenience may possibly explain the modern tendency to devote attention rather to improving the mechanism of existing pyrometers than to the development of new methods of measurement, or the application of a new principle. Such, at least, is the impression produced in following the author through his description of the devices which have been successfully employed.

As an example of the expansion principle, a chapter is devoted to the construction of the mercury thermometer and a discussion of the sources of its error. No mention is made of pentane as a substitute for mercury in the measurement of low temperatures, an arrangement that is found very useful in connection with liquid air plants. On the other hand, a novel employment of molten tin in a graphite bulb and stem, is mentioned with approval for recording high temperatures. The suggestion has good points, though we do not know how the plan has succeeded in practice. Tin is said to expand uniformly up to 1,680° C., does not form any carbide with graphite, and remains pure in a CO atmosphere. The opacity of the tube is a drawback, and it is proposed to read the height of the molten tin in the stem, by pushing a nickel wire through a gland at the top, and completing an electric current on contact being made with the molten metal.

Resistance and thermo-electric pyrometers are treated in one chapter. The sources of error are adequately examined and the value of such instruments in their proper sphere is fully emphasised. Recent researches on the former in which is utilised the change in the electrical resistance of platinum with temperature as a means of measurement have given to its application such a degree of precision that it is now almost universally adopted where the highest accuracy is needed. It has been found especially suitable as a check standard, hence it is peculiarly desirable that any possible trace of suspicion in its records should be eliminated. The liability to permanent change of resistance in the platinum when used in temperatures over 1,000° C. is commented upon, and though it is mentioned that metallic solderings are volatile at high temperatures, and liable to attack the platinum, no reference is made to the possible volatibility of platinum itself, a point that was insisted upon by the late Sir W. Crookes, and one that is quite capable of explaining some of the observed discrepancies. A possibly more convenient form, and, if base metals are used, a more robust type of pyrometer, is found in the thermo-electric couple, consisting essentially of two dissimilar metals joined together at one end, and connected at the other to the terminals of a galvanometer. Many metals and alloys have been recommended and their merits and defects are fully discussed. All are liable to change in calibration after long exposure to heat, due to structural change in the alloy. For the maintenance of accuracy there is needed, beside the primary calibration of the outfit, periodical verification to test the accuracy of the measures under working conditions. Moreover, the thermo-electric method does not possess the necessary sensitiveness for low temperature work, and fluctuations in the temperature of the cold junction introduce some difficulty. Placing the cold junction in a vessel buried in the ground has been proposed, and might be satisfactory in some conditions, but could hardly be recommended in the vicinity of a group of steel furnaces. The measurement of electro-motive force by the galvanometer and potentiometer methods is well described, but where such instruments are used the examination and test would probably be left in the hands of an expert.

These forms of pyrometer are rarely used for the measurement of temperatures exceeding 1,000° C. For higher ranges, encountered in many industrial processes, it is convenient to employ radiation and optical pyrometers, a modification which possesses the advantage that such instruments do not require to be submitted to the temperature of the metal to be measured. For the proper appreciation of the theory of such instruments, some acquaintance with the laws of radiation is needed; as in the case of the radiation pyrometer of the Féry form, the introduction of Stefan's law is necessary for adequate explanation; and in the optical pyrometer of the Wanner type, Wien's law. It is therefore somewhat disappointing to be referred to other works by the author for information which might well have appeared here. Certainly, Mr. Royds is justified in saying that "no more is given than is required for the understanding of the construction and uses of the particular instruments required," but this minimum amount is annoying to the inquirer. Will he not find a difficulty in realising "black body" conditions, and in appreciating the necessary fulfilment between these conditions and those that obtain in uniformly-heated furnaces or muffles? But those who are content to use an instrument without being too critical concerning the principles on which its construction rests, will find much useful information here that will prevent the commission of many errors, and ensure a very tolerable degree of accuracy in the results. The ingenuity displayed in the mechanism of some of the forms should excite the admiration of the practical man, and the description lends an increased interest to this chapter.

Two short chapters follow on contrivances that indicate, but do not measure, temperature, and on calibration. In the former it is interesting to mark that in the pottery industry it is still customary to gauge the firing temperature by a set of clays possessing progressive fusibility, and that improvements in the form and sensitiveness of the cylinders and cones used for noting furnace effects still engage the attention of makers. The work of calibration or the determination of errors on graduated instruments is rightly made very short, for the work must necessarily be left to experts operating delicate mechanism not usually at the command of those using the instruments.

The final two chapters are devoted to the application of the instruments previously described, and an examination of the results derived. In the penultimate, the temperature of a metal wall under varying conditions is made the subject of inquiry, and in the last, the measurement of rapidly fluctuating temperatures. The history of the subject is traced from the early experiments of Mr. Bryan Donkin, who used mercury thermometers inserted in drilled holes for the measurement of cylinder wall temperatures, down to the most recent application of more refined apparatus. Where thick walls have been the subject of inquiry, later physicists have followed Mr. Donkin's plan, but mercury thermometers are useless when the temperature of moving parts, such as that of a gas-engine piston, is needed, or when the object of inquiry is the temperature of a thin water tube. Then are well illustrated the resources of the ingenious contrivance of the thermal couple and other devices Mr. Royds has so well described. Particularly instructive will be found the methods of working adopted by such masters in pyrometry as Professor Callendar and the late Professor Hopkinson. The determination of errors and the interpretation of results are not simple pieces of work, and the author's remarks and criticisms should be welcome to those who are tempted to emulate the example of others who have successfully attacked problems of great difficulty.

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Locomotive Boiler Construction for Boiler Makers, Boiler Users and Inspectors. By Frank B. Kleinhans and George L. Fowler. London: Page and Co. [Price 18*s.* net.]

INDUSTRIAL NOTES.

The Highways Committee of the London County Council having recommended the acceptance—owing to its comparatively low price—of a tender submitted by Messrs. Brown, Boveri and Company, Baden, Switzerland, for an 8,000-kw. turbo-generator in connection with the extension of the Greenwich power station, Mr. D. A. Bremner, director of the British Engineers' Association, wrote the London County Council saying that if the order had been placed in this country at least 80 per cent. of the purchase price would have been distributed amongst our own people in the form of wages and salaries. Our cost of manufacture was relatively high because of the larger amount of purchasing power demanded by our workers in return for their production of a given commodity value. The London County Council replied—without further comment—that they had decided to accept Messrs. Brown, Boveri and Co.'s tender since it was about 8,000*l.*, or about 16 per cent. lower in amount than the lowest acceptable British tender. Commenting upon the transaction in the daily press, Mr. H. Hirst, chairman of the General Electric Company, Limited, said in placing this contract for about 40,000*l.* abroad, the London County Council justified their action by stating that they saved about 7,000*l.* Mr. Hirst maintained that the county not only did not save that sum, but lost about 25,000*l.* by the work going abroad, namely, 15,000*l.* to 18,000*l.* in direct wages to engineering trades and probably another 10,000*l.* in wages spent on raw materials. The British worker had lost the work; the foreign manufacturer got a fine advertisement, and if he chose to use German material he could even make a big profit. The only benefit to the British manufacturer would be the prospects of a higher rate of contribution to the unemployment funds.

Speaking last week at the seventh annual general meeting of the Mond Nickel Company, Limited, the chairman, Mr. Robert Mond, J.P., stated that all wages of their workmen were settled through the intermediary of the Chemical Employers' Federation, of which the company were members. They had found this procedure to have many advantages over the system by which they settled these matters single-handed with their workmen. Considerable time had been saved to their technical staff, thus enabling them to devote more attention to greater efficiency and economy. The settlement of wages he referred to had been the means of bringing about a closer approximation to a uniform rate of wages in the chemical trade. In November, 1920, the Industrial Court, as a result of a combined wage application from the various unions, awarded an advance of 3*s.* 6*d.* per week plus 12½ per cent. The employers, however, were convinced that the advance was not justified, and that it was essential, in order to place the industry on a sound basis, to secure a substantial reduction in costs of production towards which the cost of labour contributed the major portion. As a result of joint action by employers working through the Federation, a reduction was agreed by which the labourers' wage was brought down to 1*s.* 5*d.* per hour, and that of shiftmen to 1*s.* 7*d.* per hour to take effect as regards the company's workmen on July 1 last. This rate was 146 per cent. above the pre-war rate in the case of labourers and 201 per cent. in the case of shiftmen. In the present temper of labour it was indeed a difficult task to convince the rank and file of the imperative necessity of reducing the cost of production to a level which would enable British manufacturers successfully to compete in foreign markets.

In agreement with the sliding scale arrangement for the manufactured iron and steel trades of the North of England, the wages of iron workers for August and September will be reduced by 47½ per cent. The accountants' declaration states that having collected from the firms associated for the purpose with the Board of Conciliation and Arbitration, the returns of the sales of manufactured iron for the two months ended June 30, they certify the net selling price per ton to have been 19*l.* 3*s.* 8·19*d.*, the weight invoiced being just over 255 tons. A year ago the total make was 7,722 tons, and the selling price 28*l.* 8*s.* 0·24*d.* For January and February the return involved a reduction of 25 per cent., March and April, 30 per cent., and the last return 47½ per cent., making a total of 102½ per cent.

A meeting was held in London last Tuesday, when the wages and working conditions of skilled craftsmen in railway engineering shops were discussed between the negotiating committee of railway general managers and representatives of the National Union of Railwaymen, the Federation of Engineering and Shipbuilding Unions and the National Federation of Building Operatives. An official statement, issued after the meeting, stated that the whole position of the shopmen and the application of the reduction recently agreed upon with the Engineering Employers' Federation had been considered. It was agreed that 6*s.* per week reduction should operate for railway shopmen from August 15, when the second of the two "cuts" of 3*s.* comes into force for engineers under the agreement with the Engineering Federation. It was further agreed that the managers should recommend to the railway companies that other matters in dispute, including the questions of overtime, night shift and district rates should be referred to arbitration for settlement.

The Amalgamated Engineering Union has a number of railway shopmen in its membership, but was not represented at the meeting. There has been a long-standing dispute between the craft unions and the National Union of Railwaymen which has held up a settlement of the shopmen's conditions. A complete settlement now depends on the decision of the Amalgamated Engineering Union; there is further the question as to whether the railway companies will agree to arbitration in the event of that union continuing to stand out. The agreed reduction of 6*s.* a week is expected to apply generally to all railway shopmen despite the fact that the Amalgamated Engineering Union was not represented at Tuesday's meeting.

The acting secretary of the Amalgamated Engineering Union, in an interview on the same day, stated the following: "We were invited to attend the conference, but we decided not to do so because we do not recognise the right of the National Union of Railwaymen to negotiate on behalf of the shopmen. We will not negotiate with the National Union of Railwaymen until they cease to do harm, as they have in many instances, to the skilled workers in railway engineering shops. Some of their agreements have meant considerable reductions to skilled men. The National Union of Railwaymen do not understand the conditions of the skilled men, and are therefore not competent to negotiate for them. We have already been in direct negotiation with some of the companies and the railway managers, and have completed negotiations with the Great Central. Our policy will be to negotiate directly and independently with the companies."

At the meeting of the National Coal Board, held last Tuesday, Sir William Plender was appointed the independent chairman under the terms of the recent settlement. The Lord Chief Justice was asked to make the appointment, and both the coalowners and miners agreed to his selection of Sir William.

The following reductions in gas fitters' wages were agreed upon at a recent conference between representatives of the Birmingham, Walsall, West Bromwich, and Smethwick Gas Departments and the Birmingham and District Master Gas Fitters, for the employers, together with delegates representing the National Gas Fitters' and Allied Workers' Trade Union:—

From the 1st inst., 1½*d.* per hour to 2*s.* 0½*d.* per hour.

From October 1 next, 1½*d.* per hour to 1*s.* 11*d.* per hour.

The agreement provides that after the latter date wages will be regulated by a sliding scale based on the Board of Trade index number of the cost of living, and for every five points variation in the index number from a basis of 134 points, wages will rise or fall ½*d.* per hour. This is to become operative from the first pay day in November following the publication of the October index number. After November, wages are to be revised every three months in the light of the cost of living figures for the previous three months. If and when the index number of cost of living falls to 70 above the pre-war level, the whole situation will again be reviewed.

Driving by Means of Superposed Belts.—In the rolling mill of the wire works of the Gelsenkirchen Bergwerks, A.G., at Eschweiler, 1,000 h.p. have, since 1910, been transmitted to four sets of rolls by four belts, which are superposed on one fly wheel. Each group drive consists of two rolls and in addition an idler, the three pulleys being so arranged that the belt encircles the idler, is then by a reverse curve carried round the first roll and then reversed again on the second roll, the latter two arcs of contact considerably exceeding 180 deg. The fly-wheel speed is 30 m. (100 ft.) per minute; the widths of the four belts are 1000, 700, 650, 600 mm. (40 in. to 24 in.) respectively. Some doubt may be felt as to the wear of such belts and as to the advantages of the drive; but according to the Zeitschrift des Vereins Deutscher Ingenieure, of June 25 last, the whole gear is very compact and accessible, and the attention is simpler than with the usual arrangement, and has not given any particular trouble. The method, which is due to Gebrüder Klein, of Dahlbruch, has hence been adopted on several other plants. The mills were worked at their utmost capacity during the war and the belting has thus stood severe tests.

THE SEASON-CRACKING OF BRASS AND OTHER COPPER ALLOYS.*

By H. Moore, O.B.E., B.Sc., F.I.C., Member; S. Beckinsale, B.Sc., A.I.C.; and Clarice E. Mallinson-M.B.E., B.Sc.

(Communication from the Research Department, Woolwich.)

Introduction.—During a period of some years the Research Department, Woolwich, has been called upon to investigate the occurrence of season-cracking, or, as the authors have termed it elsewhere,† stress-cracking, in many types of war stores made of copper alloys, for example, cartridge cases. Numerous specimens in which this type of failure has occurred have been examined and much time has been devoted to the investigation of the causes of season-cracking, the detection of liability to fail in this way, the mechanism of the process by which the cracks form and develop, the effects of variations in composition, structure, and physical properties such as hardness, and the prevention of season-cracking. For the present paper the authors have selected such of this work as appeared likely to be of general interest and to assist others who may have occasion to study the question. Certain sections of the experimental work included, having been carried out in connection with some immediate practical problems, may not appear to be closely related to the main lines of the investigation but in such cases the authors have thought it well to give the experimental results which they have taken into consideration in arriving at their conclusions. In an unpublished report dated 1906, F. Rogers stated that failure of cartridge cases by spontaneous splitting appeared to be due largely to the existence of undue internal stress, and described the use of solutions of mercury salts for the detection of internal stress in brass. The dependence of "spontaneous" cracking on a state of tension in the brass had been suspected for some time previously. E. Heyn devoted the 1914 May lecture to this Institute to a full consideration of the existence, causes and effects of internal stress in metals, which was indicated as a cause of season-cracking or spontaneous cracking. Methods of demonstrating the presence of such stresses were described, among these being the application of mercury, in suitable form, to brass. Internal stresses might be rendered effective in causing cracking by the added agency of further stresses caused by external forces or by unequal heating or cooling, or of surface injury as by scratching or corrosion. Methods of avoiding the production of internal stress, and of removing it by annealing, were indicated. Subsequent work has to a large extent been confirmatory of Heyn's conclusions, but reference should be made to the definitely intercrystalline character of season-cracks pointed out by W. Rosenhain and S. L. Archbutt, who based their explanation of this characteristic and of the occurrence of season-cracking on the properties of the amorphous intercrystalline cement as a viscous supercooled liquid. This explanation was disputed by W. H. Hatfield and G. L. Thirkell, and has been criticised on other grounds by A. A. Griffith. Evidence will be given in the course of this paper indicating that the phenomena of season-cracking are closely related to the properties of the intercrystalline layers, though the authors' view of the relationship differs in some respects from that of Rosenhain and Archbutt. O. W. Ellis considers that the primary cause of season-cracking in internally-stressed brass is the absorption of the amorphous phase by the more dense crystalline phase and the consequent reduction in volume and increase of stress.

Examination of Material which had Failed by Season-Cracking.

1. *Spun Vessels.*—Numbers of vessels, similar in form to the spun cups described by the authors in a previous paper, but of larger size, had developed season-cracks, in some cases within a few weeks of the date of manufacture. The vessels were dome-shaped, about 16 in. in diameter and 5 in. in depth. They had been spun from 70 : 30 brass sheet of good quality 0·07 in. thick, and were well coated with shellac lacquer. Those in which cracks were found had been unintentionally submitted to the action of a mixture containing ammonium nitrate. Some of the samples examined showed only extremely fine cracks under the lacquer, others were so badly cracked that pieces had fallen out, while in others pieces had sprung out as shown in Figs. 1 and 2. The fractured surfaces visible were crystalline and bright, the coarseness differing in different specimens. The main cracks commonly ran parallel or at right angles to the flange and frequently extended into complex branching systems of finer cracks. In many cases the cracks were located in regions more or less corroded, but some specimens were free from visible corrosion; no indication of corrosion could be detected by visual inspection around the cracks found under an unbroken layer of lacquer.

Brinell hardness tests were made with a ball of 2 mm. diameter and a load of 40 kg. on the outer surface.

Microscopic Examination.—All the specimens showed a normal a-brass structure, the size of the crystals differing in different vessels. Where cracks occurred in sections examined they followed an intercrystalline path in every case. Further tests were applied to other cracked vessels and also to vessels identical in all other respects which had not, however, been submitted to those conditions of use which had resulted in cracking.

* Abstract of a paper read at the meeting of the Institute of Metals on Thursday, March 10, 1921.

† H. Moore and S. Beckinsale, "The Removal of Internal Stress in 70 : 30 Brass by Low-Temperature Annealing," Journal of the Institute of Metals, No. 1, 1920, vol. xxiii, page 225.

(a) *Tests for the Presence of Internal Stress.*—Diametral strips, 1 in. wide, were cut out of a number of vessels, some of which were cracked, by carefully milling from dome to flange. The resulting strips sprang out as shown in Figs. 3 and 4.

(b) *Mercurous Nitrate Test.*—Vessels free from cracks, pickled in nitric acid and then completely immersed in a solution containing 1 per cent. of mercurous nitrate and 1 per cent. of nitric acid, developed cracks within 3 minutes, but were left in the solution for 5 minutes. The cracks continued to develop after removal of the vessels from the solution. In these vessels it was not important to maintain fully the hardness conferred by the cold-working operations of manufacture. An annealing for one hour at 370 deg. C. (a temperature at which the hardness of cold-worked 70 : 30 brass falls appreciably) was applied to uncracked vessels to remove the internal stress. Vessels treated in this way withstood the conditions of use under which others had failed badly, did not crack under the mercurous nitrate test, and showed no springing out of diametral strips cut from them (Fig. 4). It was concluded that in such vessels the presence of high internal stress produced by spinning induced a liability to the formation of cracks under certain conditions of use, and that this liability was removed by an annealing which removed the internal stress. Vessels identical in all respects had been in use for some years without cracking, but in all cases of failure the vessels had been in the close neighbourhood of a mixture containing ammonium salts. It will be shown in a later section of this paper that ammonium salts act as powerful "accelerating agents" in the cracking of internally stressed brass.

2. *Cartridge Cases.*—Examination of cartridge cases which have developed season-cracks indicates that the usual location of the cracks is across the base and up the walls as shown in Fig. 7, or in the wall near the flange as shown in Figs. 5 and 6. Cracks also occur in the necks, and are very similar to those found in the lower parts of the walls; longitudinal cracks are first formed, and are often joined up later by transverse cracks. The form which the cracks in and near the base take appears to depend on the method of "heading," the cold-working process in which the base of the case is formed. The heading operation, which may be carried out in several different ways, is liable to introduce large internal stresses. Large numbers of cartridge cases of many different makes have been tested in mercurous nitrate solution containing 1 per cent. of mercurous nitrate and 1 per cent. of nitric acid (1·42 sp. gr.) after a preliminary pickling in 50 per cent. nitric acid solution. The cases were completely immersed, the interior and exterior surfaces being in contact with the acid and mercurous nitrate solutions. Cracks developed in a considerable number of cases; their position, form, and extent show that the internal stresses, which exist frequently to a serious degree in new cases, are chiefly confined to the base and lower portions of the wall near the flange. When cases containing shell in position were similarly treated a large proportion developed longitudinal cracks in the neck of the case.

Brinell Hardness Tests were made with a ball of 2 mm. diameter and a load of 40 kg. on all cases.

Microscopic Examination.—Such variations in structure as occur in articles made from α-brass by a series of cold-working and annealing operations were found in the

FIG. 1. SPUN VESSEL, 70 : 30 BRASS, SHOWING SEASON-CRACKS.

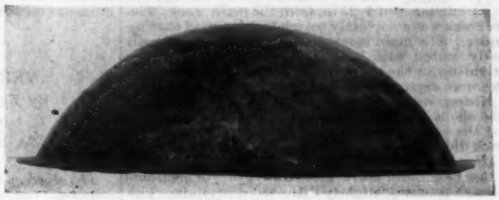

FIG. 2. SPUN VESSEL, PHOSPHOR BRONZE, CRACKED BY TREATMENT IN 1 PER CENT. MERCUROUS NITRATE SOLUTION.

FIG. 3. SPUN VESSEL, 70 : 30 BRASS, AND DIAMETRAL STRIP CUT FROM AN IDENTICAL VESSEL, SHOWING THE AMOUNT OF SPRINGING OUT.

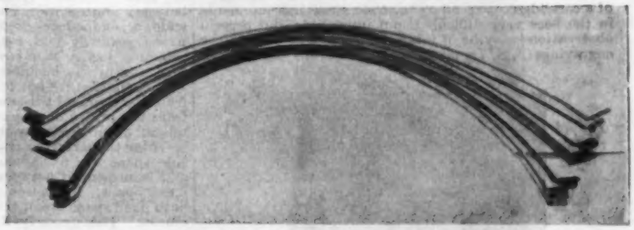

FIG. 4. DIAMETRAL STRIPS, CUT FROM SPUN VESSELS, 70 : 30 BRASS, IN SOME OF WHICH THE STRESSES HAD BEEN RELIEVED BY ANNEALING. SHOWING VARIATION IN AMOUNT OF SPRINGING OUT.

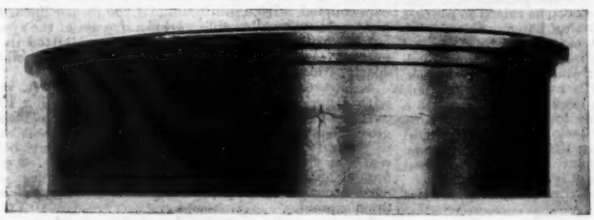

FIG. 5. SEASON-CRACKS IN EXTERIOR OF WALL OF CARTRIDGE CASE.

FIG. 6. SEASON-CRACKS IN INTERIOR OF WALL OF CARTRIDGE CASE.

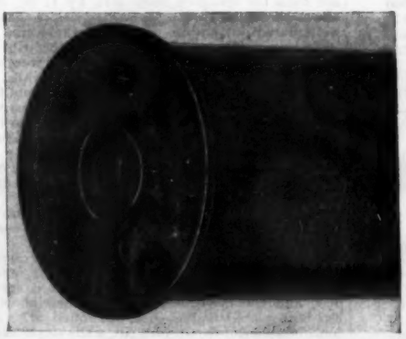

FIG. 7. SEASON-CRACKS IN BASE AND WALL OF CARTRIDGE CASE.

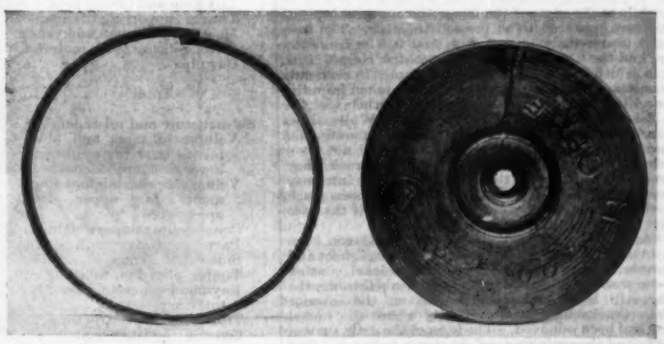

FIG. 8. BASE OF CARTRIDGE CASE SHOWN IN FIG. 7, AND RING CUT FROM PERIPHERY SHOWING SPRINGING IN.

cases examined, and the regions traversed by season-cracks failed to show any distinguishing feature in common, such as large or small size of crystal, smooth or irregular crystal boundaries, or marked presence or absence of indications of deformation of crystals. The paths of the cracks were in all cases intercrystalline.

Detailed Examination of a Typical Case.—The cartridge case shown in Figs. 7 and 8 had cracked in store.

(*a*) *Visual Examination.*—The case was well coated with shellac lacquer. In addition to the large open crack shown in the photograph there was a smaller crack of the same type running down the wall and partly through the flange, at a distance of 1·25 in. from the main crack. The smaller crack was completely covered with a good coating of lacquer. The main crack also appeared to have been originally coated with lacquer, the coating being very good right up to the edges of the crack. The fractured surfaces were crystalline in appearance.

(*b*) *Measurements.*—The cracking of the case had brought about a slight increase in the diameter of the base of the case at right angles to the crack, although the crack did not extend to the centre of the base.

(*c*) *Microscopic Examination* of the base and sections of the case near the crack revealed a structure of medium-sized, much twinned, slightly distorted α crystals. The brass was reasonably free from inclusions. The cracks had the intercrystalline form typical of season-cracks.

(*d*) *Brinell Hardness Tests* were made in the positions indicated, on the base and walls of the case, using a ball of 2 mm. diameter and a load of 40 kg.

(*e*) *Measurement and Distribution of Stress.*—The shape of a cartridge case renders accurate stress measurements in the base very difficult if not impossible, but certain observations may be of interest. As will be seen in the engravings (Figs. 7 and 8), the crack was fairly wide in the

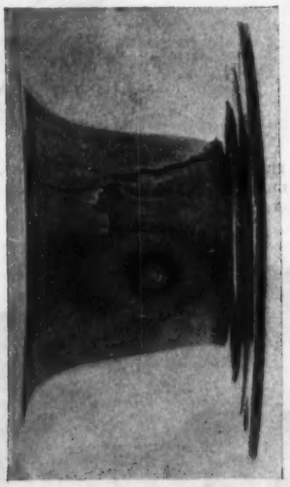

Fig. 9. Season Cracks in Mouthpiece of Klaxon Horn.

wall, while at the edges of the flange the opposite faces of the fracture appeared to be pressed together. The case was cut transversely at 0·2, 0·4, and 0·6 in. from the flange, and the base was cut into concentric rings 0·1 in. wide, a width of 0·075 in. being consumed in each cut. After cutting, the fractures in the sections taken from the wall and in the flange section sprang together and the rings taken from the base sprang open. While these movements point to the existence of important initial stresses, and also show that the stresses had not been completely relieved by the formation of the crack, they do not constitute data for the calculation of the intensity of those stresses, which would probably have been much reduced by cutting into concentric rings even if the base had not been cracked.

3. *Klaxon Horn.*—The mouth-piece of a Klaxon horn is shown in Fig. 9; it had been spun from brass sheet and afterwards nickel-plated. Some of the nickel coating had been worn off the outside by periodical cleaning, the coating still being fairly continuous on the interior surface. Cracks had developed only where the nickel coating had been removed. The form of the main system of cracks and the springing out are shown in Fig. 9. The horn had been on a motor bicycle for three years during which the bicycle had been in frequent use. The mouth-piece was cut transversely into rings, care being taken to prevent distortion. The rings which were cracked across sprang out, while the others were cut longitudinally after the dimensions had been taken. By applying to the measurements obtained the formula

$$\text{Stress} = \frac{E\,t\,W}{\pi\,d_1\,d_2}$$

given by Hatfield and Thirkell, the stresses in the rings were calculated. In the formula, t = thickness, E = modulus of elasticity, W = width of opening, d_1 = diameter before release of stress, d_2 = diameter after release of stress.

E had been determined in tensile tests of 70 : 30 brass of similar hardness as 7,300 tons per sq. in., and this was the value used.

The cracks appeared to have started in the region between 0·6 in. and 1·4 in. from the mouth of the horn and to have extended to the less highly-stressed regions.

The copper content of the brass was 68 per cent.

Microscopic examination showed that the cracks passed along the boundaries of well-formed crystals.

The vibration to which this specimen had been submitted, transmitted from the motor bicycle and from the diaphragm of the horn, had evidently not reduced the internal stress to a safe limit, and was probably without influence on the intensity of the internal stress.

(*To be continued.*)

VERTICAL LIFT BRIDGES.*

By Ernest E. Howard, A.M.Soc.C.E.

(*Concluded from page* 236.)

Part IV.—A Bridge with a Lift Span which has a Lifting Deck.

The Harriman Bridge over the Willamette River at Portland, Ore.—The Oregon-Washington Railroad and Navigation Company's Willamette River Bridge at Portland, Ore., completed in 1912 at a cost of 1,715,000 dols., is a double-deck structure which is 1,900 ft. long between the ends of the upper deck approaches, Fig. 8. The lower deck extends across the river only and, including short approach spans on one side, is 900 ft. long between abutments. The upper highway deck, 73 ft. wide, accommodates double street-car tracks, and has a paved roadway and two sidewalks; the lower deck provides for a standard double-track railway. The bridge is in the business district of Portland near the Union Station. The railroad tracks enter the deck from the terminal yards with a curve of 15 deg. and pass from the bridge on the opposite side of the river, both up and down stream, with 16 deg. curves.

Of the three riveted truss spans over the river, the two side spans are fixed, and the centre span is movable and is suspended between two towers supported on the fixed spans. To accommodate the track alignment, both fixed spans are of the spread type with non-parallel trusses. The westerly fixed trusses, 287 ft. long, are 34 ft. at the river end and 40 ft. 3 in. at the shore end between centres; the easterly fixed trusses, of the same length, are correspondingly 34 ft. and 71 ft. 6 in. between centres. The fixed spans have the railway floor near their lower chords and the highway deck above their top chords.

The movable span is a through truss lift span for the highway floor, with a suspended lifting deck for the railway floor, Figs. 9 and 10. For the passage of a river steamboat or tug this lifting deck can be raised to contact with the upper floor, its supporting hangers telescoping into the posts of the upper trusses, affording vertical clearance of 72 ft. above ordinary low water. Such movement does not interrupt traffic on the upper deck. For the passage of vessels with masts the lift span, including the suspended lifting deck, may be raised to a height of 140 ft. above extreme high water, or 173 ft. above low water. The lifting deck may be fully raised or lowered in 30 seconds, and the lift span in 60 seconds. Operation is by electric power; the total moving load with the lifting span in operation is about 4,600 tons.

Approximate Quantities.—The approximate quantities in the structure are :—

	Tons.
Superstructure metal :	
Upper deck approaches	1,209
Lower deck approaches	103
Fixed truss spans (2)	4,262
Lift span and lifting deck ...	1,600
Towers supporting lift span ...	871
Machinery on span and towers ...	559
Street railway track material ...	125
Gas pipe	51
Total	8,780

Substructure and miscellaneous :	
Volume of piers and abutments on river spans and lower deck approaches ...	23,300 cub. yd.
Volume of pedestals and abutments for upper deck approaches	6,700 cub. yd.
Concrete in counterweights...	1,080 cub. yd.
Paved roadways	10,300 sq. yd.
Sidewalks	2,600 sq. yd.
Timber piles 704, totalling ...	35,000 lin. ft.
Raymond concrete piles 222, totalling	7,875 lin. ft.
Timber in superstructure ...	700,000 ft. B.M.
Cement	38,000 barrels

Construction began in May, 1910, and was completed in August, 1912. The movable span is absolutely unique —a logical solution of the problem offered.

Confronting Conditions.—The Willamette River flows northward through the City of Portland and discharges into the Columbia River some 8 miles distant. The principal business district of the city and a large residence section are west of the river, and to the east the largest residence section and some business and industrial enterprises are located. This produces an enormous trans-river highway traffic over the five existing bridges, each of which has a movable span. The Oregon-Washington Railroad and Navigation Company's tracks enter the city from the east and the Southern Pacific tracks from the south, and all trains must cross the river to reach the station and terminals on the west side. These were formerly served by a double-deck bridge known as the "steel bridge," built about forty years ago, with a single railway track below, and a 32-ft. roadway above for street cars and highway traffic, and included a 340-ft. swing span.

There is in the Harbour of Portland a large amount of shipping, including river steamboats, tugs, and small craft, ships and sailing vessels, lumber schooners, tramps and ocean liners. Few river harbours in the United States have a greater number of vessels passing daily. The constant movement of this river traffic requires frequent operation of the movable spans, interferes seriously with travel across the bridges, and causes repeated congestions of vehicular, street-car, and pedestrian traffic. The records of the old steel bridge for one year show 35,000 operations. Allowing the minimum of 5 minutes per round-trip operation, the draw thus stood open about 8 out of every 24 hours. Study of the character of the river traffic showed, however, that about 80 per cent. of all such vessels could pass under a bridge 60 ft. high.

These conditions confronted the officials of the railway company when, because of deterioration of the old structure and the need of double-track facilities for heavy loading, the question of a new bridge was taken under consideration. A combined railway and highway bridge was desired, with a railway deck at the low level of the terminal yards, and a highway deck so high that the approaches would pass over the adjacent yard tracks. It was evident that there would be interruption to traffic on the highway deck only a few times daily if the lower deck could be made to operate independently of the upper one for the passage of river steamers.

To meet these conditions the writer proposed the double-action lift span. Preliminary plans and estimates were submitted and although no such structure had ever been built, the railway officials were convinced that no problems would be involved not soluble along rational well established lines. In addition to advantages of operation, comparative estimates of cost showed that the bridge with the double-action lift would cost 250,000 dols. less than a bridge including an ordinary double-deck swing span.

Loading and Specifications for Design.—The Harriman Lines' Common Standard Specifications Nos. 1,006 and 1,012 for railway and highway bridges, with slight modifications and supplemented by special requirements, were used for design. The assumed live loads were as follows: For the railway, two consolidation locomotives, Class E. 55, followed by a uniform load of 5,000 lb. per linear foot; for the highway, a 24-ton truck in a space 12 ft. by 20 ft., and 100 lb. per square foot over the remaining area; and for street-car tracks, two 50-ton cars coupled, with a minimum of 1,200 lb. per linear foot per track. The allowable working stresses of the specifications are somewhat less than those permitted in the current American Railway Engineering Association specifications for railroad bridges.

Substructure.—The river at the site is 800 ft. wide, with a maximum depth of 90 ft., and exceeding 40 ft. over most of its width. Hard conglomerate—"cemented gravel"—exposed at the water's edge on the east bank, is 125 ft. below low water at mid-river, and quite below reach at the west bank. The east side afforded good foundations for approach pedestals, but piles were needed on the west side, as much of the area there is filled ground.

The two main piers are founded on hard cemented gravel, one 120 ft. and the other 130 ft. below low water. These were constructed by the open dredging process. Their bases are 36 ft. wide and 72 ft. long. Each is a timber crib filled with concrete. The crib contained six wells for dredging, each 9 ft. by 11 ft., from 11 ft. above the cutting edge, upward. Below that point the wells flared out and occupied the whole area of crib at its bottom. The entire perimeter of the crib, its central longitudinal wall, and two cross-walls, were shod with heavy steel cutting edges. The crib walls, generally 1 ft. thick, had the spaces between them filled with concrete, as the cribs were settled to position, thus making walls of timber and concrete, 5 ft. to 6 ft. thick, around the wells. After being duly founded on the bed-rock, these wells were filled with concrete deposited under water up to a point where it was convenient to pump out and place the concrete in the open. The tops of the cribs are about 20 ft. below water, where the neat work of the shafts begins. The shafts were constructed within removable timber coffer dams bolted to the cribs.

Excavation for Pier Base.—A substantial dock of about 100 piles, braced and capped, was first built for each pier. Borings were made over the area to be covered by the pier, and the elevations of hard material determined. For both piers this bed-rock was found to be on a very considerable slope. In pier No. 4 the slope amounted to 19 ft. between diagonally opposite corners ((Fig. 11). Pipes 4 in. in diameter were driven down through the river bed of sand, gravel and clay to hard material, successively, over the entire area of the pier at intervals of 6 ft., and holes were drilled into the hard material to a selected elevation. The contained material was washed out of the pipe by a jet, and a 4-in. drill bit on a 2-in. pipe was used inside the larger pipe to drill into the hard material. When 5 ft. or 6 ft. of the hole had been drilled, the drill was withdrawn, and a sheet-iron tube, 2½ in. in diameter and about 5 ft. long, loaded with dynamite and powder, was carefully lowered to the bottom of the drilled hole, and weighted. The casing pipe was drawn up about 10 ft. and the charge fired. The casing pipe was then driven down as far as possible, and the drilling started again. This process was repeated at intervals, deemed sufficient to produce a bottom uniform in character over the area of the pier base. The blasting

* Paper read before the American Society of Civil Engineers, May 4, 1921.

of the bed-rock material was thus carried on before any excavation was begun in the 40 ft. to 70 ft. of overlying river-bed material.

The lower 30 ft. of the pier crib was built on shipways, on shore. It was launched and floated to a position within the temporary dock which was then finished and closed. Concreting in the wall spaces and building up the timber walls proceeded simultaneously. The dredging for sinking the pier was done with orange-peel and clam-shell buckets, and with a hydraulic jack, or water siphon, operated by large pumps. In each pier the area blasted out proved to be too small, for when nearing final position the pier hung on the sides of the excavation. Additional blasting in holes drilled 4 ft. outside the cutting edge blew the material inside so it could be removed, and the crib finally reached a satisfactory position practically at the elevation predetermined.

The total height of each pier is about 145 ft. and each contains about 8,650 cub. yards. The total load on a pier foundation, including live, dead and pier load, is practically 16,000 tons. Ignoring side friction, the intensity is 6 tons per square foot. The side friction developed during sinking was calculated to be 550 lb. per square foot, and with this friction the net load on the foundation would be 3·7 tons per square foot. The river has practically no ice, and the pier shafts are of concrete without special protection.

The east main abutment is near the water's edge. The extreme depth of water was only 25 ft., but conditions for coffer dam construction were difficult because the cemented gravel bed-rock, too hard to be penetrated by a steel shod wooden pile, was overlaid only by a few feet of loose, round boulders. Two rows of old steel rails, 5 ft. apart, were driven into the hard material. Waling timbers were fastened to these rails and triple-lap wooden sheet piling was placed within and driven to the hard material. A rich grout mortar was deposited in the coffer dam through a pipe, to cement the boulders together and make a seal to the cemented gravel. The space between the walls was filled with clay and loam, and a quantity of mud and gravel dredged from one of the river piers was piled against the river side of the wall. The coffer dam was then pumped out and work proceeded in the open.

The main pier at the west bank rests on piles driven and sunk by water jets within a timber crib, to about 90 ft. below low water. The crib is 33 ft. by 69 ft. by 25 ft. deep, and contains 233 piles. The construction was very similar to that described for the Interstate Bridge piers. The pedestals and abutments were of usual construction, partly on soil, partly on timber piles, and partly on concrete piles.

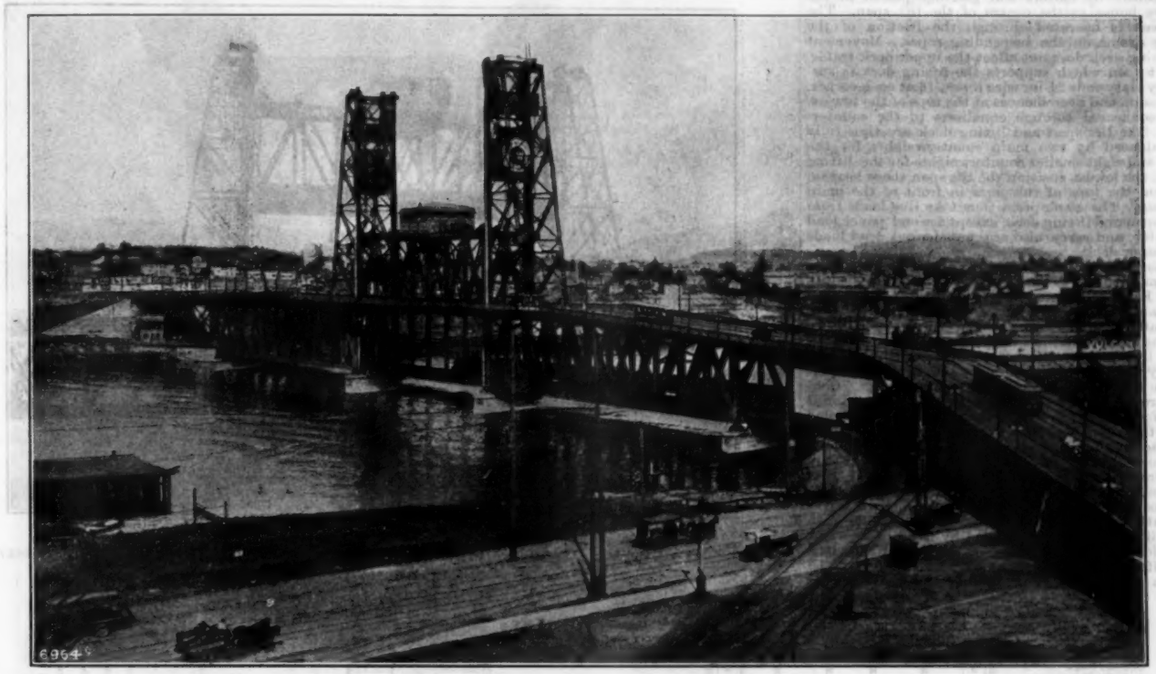

FIG. 8. HARRIMAN BRIDGE: VIEW OF COMPLETED STRUCTURE LOOKING EAST, SHOWING ENTRANCE OF RAILWAY TRACKS AT WEST END, AND RELATION OF HIGHWAY APPROACH.

FIG. 9. HARRIMAN BRIDGE: VIEW SHOWING LIFTING DECK RAISED; RIVER STEAMBOATS PASSING BENEATH.

Superstructure.—Over the three river spans the upper deck is 73 ft. wide, with a central roadway of 27½ ft., two side roadways of 15 ft., and two 6-ft. sidewalks. The approaches are, in general, 55 ft. wide, with one 42-ft. roadway and two 6-ft. walks. The grades and alignment of the upper deck approaches were restricted by physical conditions, and somewhat by civil authorities. The west approach has a grade of nearly 7 per cent., and the east approach a grade of 2·5 per cent.

These approaches are steel viaducts of the usual type. The floor is of 4-in. creosoted plank on creosoted fir ties, with creosoted wood block pavement. The hand rails are of heavy steel design. The sidewalks are of plank covered with an asphaltic preparation ¼ in. thick. The street-car rails are 8 in. high.

Towers and Machinery.—The towers (Fig. 12), from which the lift span and the lifting deck are suspended, are integral parts of the fixed spans. The main posts, which support all the weight of the lift span and its counterweights and about three-fourths of the weight of the lifting deck and its counterweights, rest on the shoes which also serve the fixed spans. The rear posts of the towers connect at the second panel points of the spans, and support about one-fourth of the weight of the lifting deck and counterweights. The main sheaves which support the lift span rest on bearings built up from trusses connecting the front tower posts. The sheaves for the lifting deck rest on girders at the tops of the towers. The towers are so wide that both counterweights can move within them. The main counterweights are suspended just back of the front posts. The lifting-deck counterweights are back of the main counterweights, requiring double sets of sheaves.

The towers are designed for a wind pressure of 15 lb. per square foot with span moving, and 30 lb. with the lift span down. The total load on each main post shoe is 3,250 tons, which is supported on a cast steel base, 12 ft. by 12½ ft. The load is carried into the shoe by a pin, 13½ in. in diameter, in bearing over its full length. A steel casting riveted between the gusset plates and supporting the tower post affords bearing on the pin.

The lifting deck is a usual double-track railway deck of stringers and floor beams with a lower lateral system and bottom chords. It is suspended from the trusses of the lift span by stiff member hangers which rise centrally inside the truss posts when the deck is lifted. The end shoes on the piers, the supporting pins and diaphragms, end locks and hanger locks, and other details are similar to those of the North Kansas City Bridge. Each pair of hangers is suspended by eight 1¼-in. wire ropes, four to each hanger, which connect

to a counterweight through equalisers. These suspending ropes extend from the hangers up through the truss posts, over sheaves above the panel points of the lift span, thence under grooved drums at the corners of the lift span, thence up and over sheaves on the tops of the towers and so to the counterweights. The end floor beam has only two ropes at each end. The pairs of drums at each end of the lift span are connected by transverse shafting, and the four drums are revolving simultaneously by motors and gearings placed in the machinery house at the centre of the lift span. The lifting deck is operated through the friction of the operating drums on the suspending ropes. Movement of the lifting deck does not affect the upper deck traffic.

The lift span which supports the lifting deck is suspended by sixty-four 2¼-in. wire ropes, 16 at each corner, which pass up and over sheaves at the tops of the towers, and are connected through equalisers to the counterweights. The lift span and lifting deck are thus fully counterbalanced by two main counterweights for the lift span, and eight smaller counterweights for the lifting deck. In the lowest position the lift span shoes bear on castings on the tops of sub-posts in front of the main tower posts. These sub-posts thus take live loads from both lift span and lifting deck, except the end panel load of the latter, and carry also any unbalanced dead loads of the span or deck.

Operation of Lift Span.—The lift span is operated by four drums actuated through trains of gears by electric motors. Each drum controls two pairs of ropes, one pair of up-haul and one pair of down-haul, in arrangement substantially as described for the Interstate Bridge. The lifting deck and the lift span are each separately operated by two electric motors, but the two sets of machinery and the four motors are connected so that it is possible to operate either with any two motors. Controllers are of the magnet control series type. Limit switches for emergency are provided both for the lifting deck and the lift span. Most of the operating machinery is in a machinery house above the top chords of the lift span; the controller, indicators and other equipment are in an operator's cabin below the machinery house, from which the upper roadway is visible. The locks close automatically, but are drawn by motors which are interlocked with the lifting machinery. Both the lift span and the lifting deck are controlled by hand brakes.

For guidance during movement, both the lifting deck and the lift span have guides at each corner engaging on tracks on the towers. For the deck these are slotted counterweights, which have guide tracks for the full height of movement. Tapered centre castings near the lower limits bring both deck and span to exact lateral positions when seating.

At the floor joints between the lift and the fixed spans, steel floor plates on the lift extend over and rest on the fixed spans when the span is down. Street-car and railway-track rails extend across these gaps by manganese

All parts of the machinery are designed with provisions for maintenance and replacement without serious interference. The machinery house is equipped with a travelling hand crane.

The bridge carries a 12-in. gas main in which continuous service at a pressure of about 60 lb. is maintained. From a section of pipe lying along the upper chords of the lift span two vertical sections of pipe are hung and

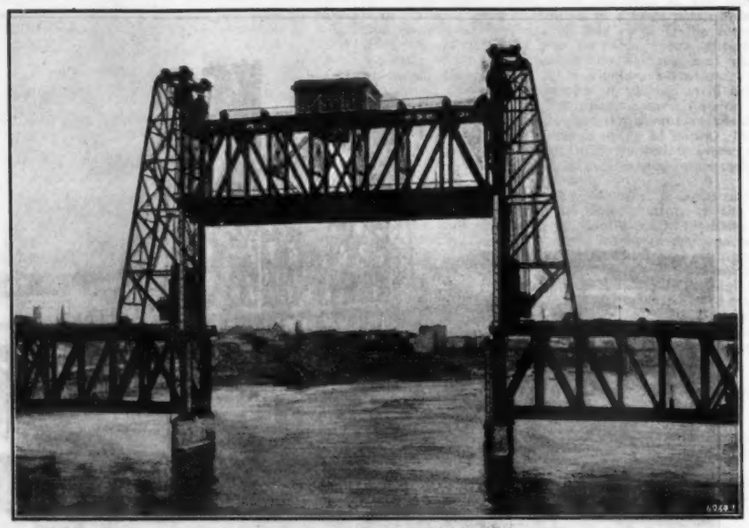

Fig. 10. Harriman Bridge: View Showing Lifting Span and Lifting Deck Raised to Extreme Height.

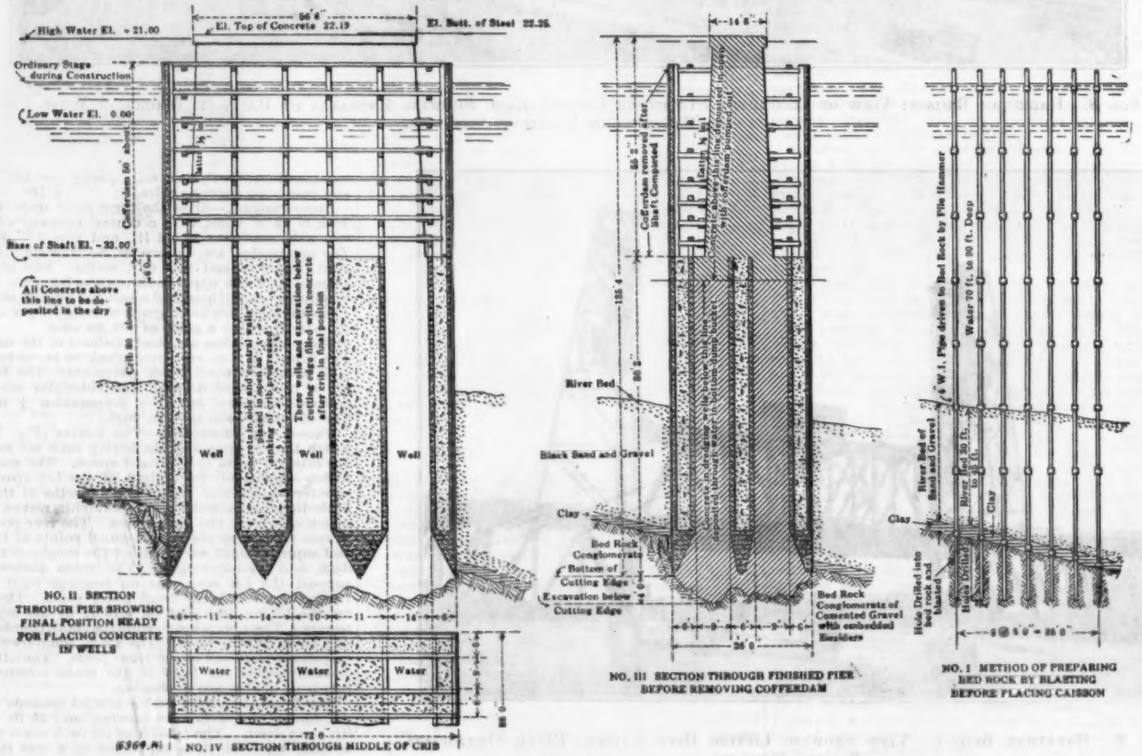
High Water El. +21.00
Ordinary Stage during Construction
Low Water El. 0.00
Base of Shaft El. -33.00
All Concrete above this line to be deposited in the dry
Well
Well
Well
Water
Water
Water
NO. II SECTION THROUGH PIER SHOWING FINAL POSITION READY FOR PLACING CONCRETE IN WELLS
NO. IV SECTION THROUGH MIDDLE OF CRIB
River Bed
Black Sand and Gravel
Clay
Bed Rock Conglomerate
Bottom of Cutting Edge
Excavation below Cutting Edge
Bed Rock Conglomerate of Cemented Gravel with embedded Boulders
NO. III SECTION THROUGH FINISHED PIER BEFORE REMOVING COFFERDAM
River Bed of Sand and Gravel
Clay
NO. I METHOD OF PREPARING BED ROCK BY BLASTING BEFORE PLACING CAISSON

Fig. 11.

jaws; for the span, double roller guides are backed by heavy springs which keep the longitudinal rollers constantly in contact with the tracks. The guide tracks for the lifting deck do not extend above the lift-span shoes. When the lift span rises, the lifting deck is held tightly in contact with it so that when the span is reseated the deck guides are properly re-entered on their respective tracks. The guides for the counterweights are similar. Each group of deck counterweights has double jaw guides engaging in turn on tracks on the towers and on short tracks on the main counterweights, so that after the deck is fully lifted its counterweights move with the main steel gap bars, which seat against the webs of the rails on the fixed spans, affording continuous tracks. There are heavy manually-operated gates for roadways and sidewalks to shut off traffic during span movement. For each right-hand, street-car track there is a derailing switch connected to, and operated by, the adjacent gate.

With extreme movement, the main counterweights descend to within a few feet of the highway floor. The street-car trolleys, within the towers, are carried on movable longitudinal bars which are pushed down as the counterweights descend, and return to their original position as the counterweights ascend.

telescope into vertical sections of larger pipe fastened to the towers and connecting to pipes carried out from shore on the lower decks of the fixed spans. There are stuffing boxes at the upper ends of the fixed vertical sections. The gas can flow uninterruptedly for any position of the lift span, and during span movement.

Erection.—The two fixed river spans were erected on falsework, which was unusual only in that the piles were of single sticks from 90 ft. to 130 ft. long. The floor system and laterals were placed by a locomotive crane, but the trusses were erected by a floating derrick

comprised of "sheer legs" 110 ft. high, mounted on the end of a large scow.

In order to avoid interruption of river traffic during construction, the lift span was erected on elevated falsework affording a vertical clearance of 116 ft. and a full 200 ft. horizontal clearance at water level. This falsework consisted of four wooden Howe trusses, 120 ft. long, which rested on eight wooden cantilever brackets built in front of, and attached to, the channel ends of fixed spans. The brackets rested on the piers, were 82 ft. high, and overhung 52 ft. The front post of each bracket was of six 12-in. by 12-in. timbers bolted together. The brackets and trusses were framed on scows and hoisted into place, each unit complete.

A timber gallows frame, 150 ft. high, hinged at its base and restrained by guy lines, was placed successively near each end of this falsework and served to erect the towers and main sheaves. The correct locations of the tops of the towers were determined by a plumb line of piano wire. Adjustment was made by raising or lowering the back columns of the towers, after which the rivets of the joints connecting these columns to the top chords were driven.

The lift-span material was placed with an overhead gantry traveller of two bents, 96 ft. high, operated first on the falsework and, later, on special stringers on the cantilevers of the span itself.

The main counterweights were built in lowered position on forms supported on sand boxes, 18 in. high, resting on timber falsework extending up from the piers. The suspending ropes were placed over the sheaves and connected, and when the lift span was completed and the counterweights set sufficiently, the sand boxes were opened, thus suspending the counterweights and relieving all the falsework under both span and counterweights. The machinery and operating ropes for the lifting span were placed and adjusted, and the span falsework was then removed.

The lifting-deck counterweights were built on low falsework supported on the upper decks of the fixed span, and the ropes for suspending the lifting deck were attached and laid in place over the sheaves and extending down into the various posts. The material of the lifting deck was brought on a barge to a position just below the lifting span, and each floor beam was riveted to its two hangers. Each such frame was hoisted into place with hangers inside the respective posts and connected to their suspending ropes. The stringers were then drawn up and erected between the floor beams, and the other material was similarly placed.

When the steelwork of the lift span and lifting deck was finished, enough additional load of steel rails and other materials to compensate for the yet unlaid decks was hoisted to the span, and it was lowered to its seat. Guides, shoes and locks of both span and deck were placed and adjusted with successive movements of the span. The flooring materials were placed on the span and deck in lower position. The spans were lifted to clear the river traffic, and the decking was placed. As soon as the lower deck was completed and before the floor of the upper deck had been fully placed, railway traffic was turned on the bridge, as the necessity for relieving the old bridge was imperative.

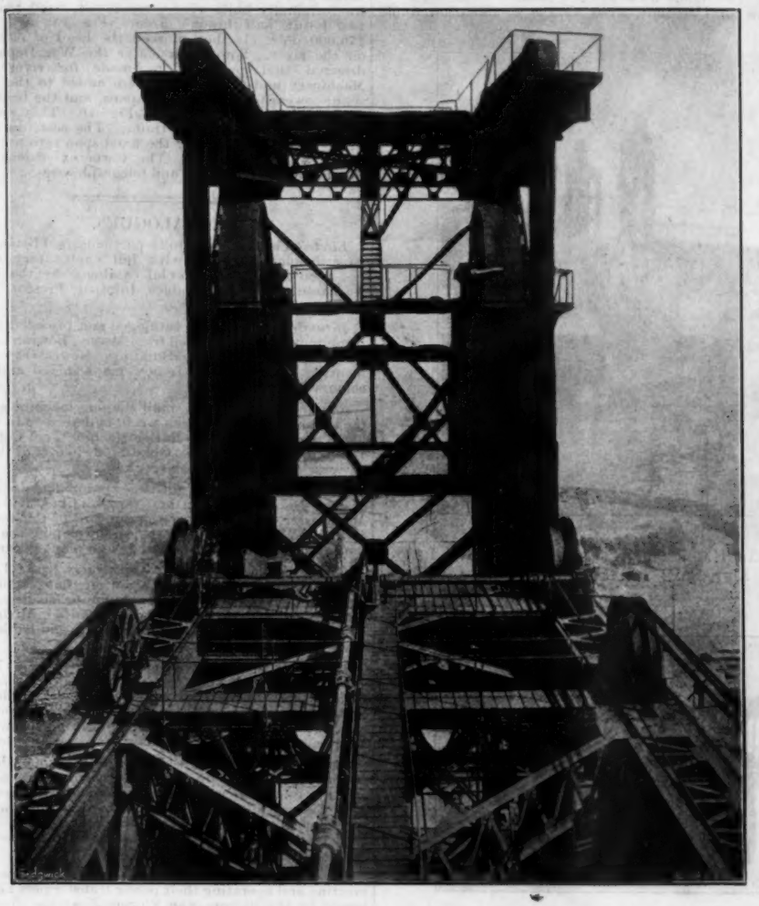

Fig. 12. Harriman Bridge: View from Machinery House, Showing Portion of Top Deck of Lifting Span and Top of Tower.

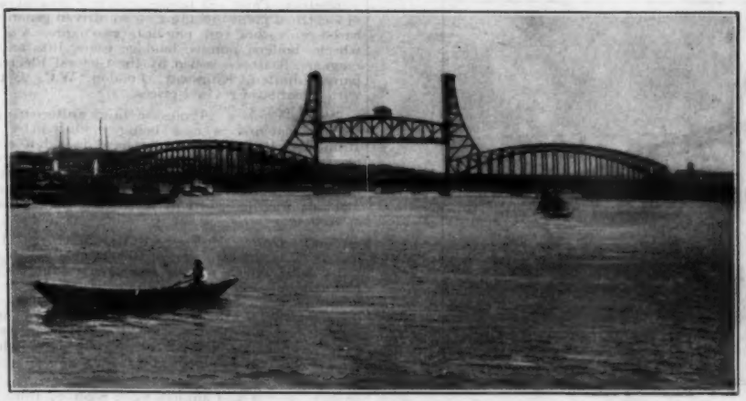

Fig. 13. Lift Bridge over Don River at Rostoff, Russia, for Vladicaucase Railway Company. Double-Track Lift Span 217 Ft. Long; Fixed Spans 317 Ft. Long. Built by Unskilled Labour; Completed in 1917, after Russian Revolution.

Table III.—*Unit Costs of Substructure, Harriman Bridge.*

	Dols.
Mass of base, piers Nos. 1 and 2, including timber, concrete, excavation, sinking, &c., per cubic yard	16·00
Mass of base, piers Nos. 3 and 4 (river piers), per cubic yard	11·25
Concrete in shafts, piers Nos. 1 and 2, including forms, cofferdams, pumping, &c., per cubic yard	7·50
Concrete in shafts, piers Nos. 3 and 4, per cubic yard	8·00
Concrete in base, abutment B, including excavation, &c., per cubic yard	17·00
Concrete in shaft, abutment B, per cubic yard	7·50
Concrete piles, per linear foot	1·32
Timber piles for amounts below bases, per linear foot	0·48
Timber piles for cut-offs, per linear foot	0·154
Cutting edges, per pound	0·09
Timber in cribs, per 1,000 ft. B. M.	48·00
Cement, per barrel	1·90

Table IV.—*Unit Costs of Superstructure, Harriman Bridge.*

	Material at Shop.	Erection.	Total.
	Cents. per Pound.		
Truss spans	2·61	1·00	3·61
Towers	2·61	1·40	4·01
Columns and bents of highway viaduct	2·89	0·60	3·49
West railway approach	2·48	0·60	3·08
Girders, highway viaduct	2·66	0·60	3·26
Counterweights, metal	2·82	1·40	4·22
Sheaves, 14 ft. in diameter	6·72	1·50	8·22
Sheaves, 76 ft. in diameter	7·78	1·50	9·28
Equalisers and pins	9·90	2·50	12·40
Wire ropes and sockets	13·10	2·50	15·60
Sheaves and drums on span	7·78	1·50	9·28
Operating machinery on span	8·84	1·50	10·34
Street railway material	2·49	1·60	3·09
Gas pipe	8·93	1·00	9·93
	Miscellaneous Costs.		
	dols.	dols.	dols.
Concrete in counterweights, per cubic yard	—	—	11·00
Motors and electrical equipment (lump sum)	—	—	19,409·00
Machinery house (lump sum)	—	—	2,000·00
Lighting system (lump sum)	—	—	2,500·00
Creosoted timber, per 1,000 ft. B.M.	30·00	15·00	45·00
Creosoted paving per square yard	1·00	1·50	2·50
Waterproofing per square yard	1·00	1·86	2·86
Concrete base and curbs, per cubic yard	2·19	5·00	7·19
Cements for counterweights, per barrel	—	—	1·90
Freight, per 100 lb.	—	—	0·80

Personnel and Prices.—This bridge was designed and built under the direction of John D. Isaacs, M.Am.Soc., C.E., at that time consulting engineer of the Harriman Lines. Mr. George W. Boschke was then chief engineer, and George T. Forsyth, M.Am.Soc.C.E., was bridge engineer, of the Oregon-Washington Railroad and Navigation Company. The engineering work of design, preparation of complete detail plans and specifications, and of supervision of construction was carried out by the writer's then firm, and occupied the especial attention of John Lyle Harrington, M.Am.Soc.C.E. The foundations were constructed by the Union Bridge and Construction Company under the personal direction of L. S. Stewart, Assoc.Am.Soc.C.E., and Mr. H. K. Saltzer. The metal superstructure was manufactured by the American Bridge Company, Albert F. Reichmann and F. W. Dencer, Members, Am.Soc.C.E., both being in close touch with the work. The erection of the superstructure, the construction of deck and the completion of the bridge were in the hands of Mr. Robert Wakefield, of Portland, Ore.

Tables III and IV give unit prices of the principal items. These units are the cost to the company, and should represent contractor's cost plus profit. The cost

of unclassified work in the substructure was 41,912·37 dols., and in the superstructure 5,694·66 dols. The large item of unclassified work in the substructure is the cost of levelling the bed-rock foundations for the main river piers which could not be pre-determined. Right-of-way costs and certain other charges are omitted.

The bridge charter and contracts provided that the city should pay to the company for the use of the highway portion of the bridge a rental based on the additional money spent to provide a combination bridge above what would have been required for an exclusive railway bridge. Careful estimates of cost were made for a bridge exclusively for railway traffic and for one exclusively for highway traffic, each to be at the same location and to afford separately the same facilities now given by the combined bridge. Omitting minor items affecting each equally, these estimates are as follows.

	Dols.
Actual cost of combined bridge ...	1,700,000
Estimate cost of bridge for railway traffic only	880,000
Estimated cost of bridge for highway traffic only	1,090,000
Additional cost of building a combined bridge	820,000
Saving in first cost by constructing one combined bridge instead of two independent bridges, about...	270,000

The total amount saved by the combination would include saving in operation, maintenance, money value of less obstruction to river traffic, &c.

Excellent records of movement of all the Willamette River movable bridges are available, and make it evident that the double movement feature of the lift span saves highway delays averaging more than 3 hours per day, or nearly five months of 8-hour days per year actual bridge service, over the service which could have been afforded by a double-deck swing bridge.

The service of the structure has been excellent throughout and its operation reliable. The mild winters in Portland permit river navigation throughout the year, so that the lift span and lifting deck are in constant service.

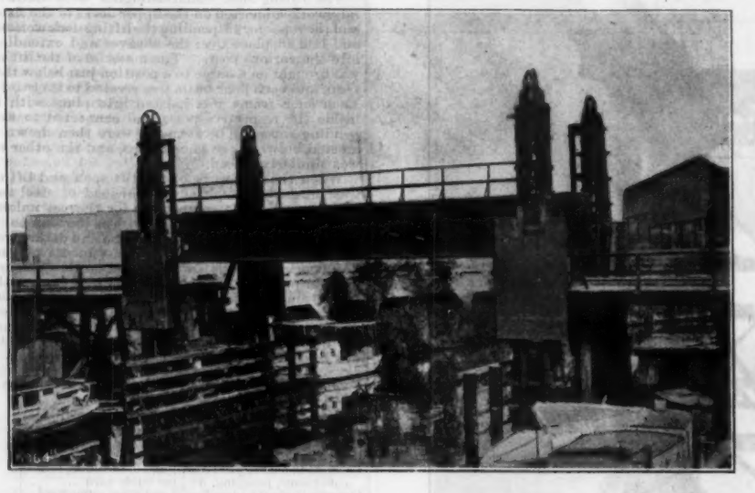

Fig. 14. Railway Bridge over Brays Bayou, near Harrisburg, Tex. Inexpensive Lift Bridge 50 Ft. Long, with Wooden Towers; Lift Span in Raised Position 20 Ft. above High Water.

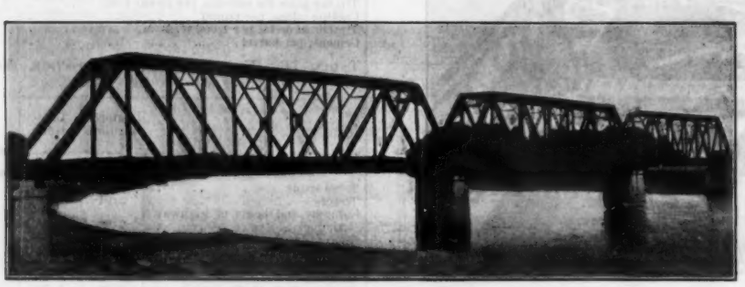

Fig. 15. Bridge over Willamette River at Harrisburg, Ore., as Originally Built—Three 200-Ft. Fixed Spans.

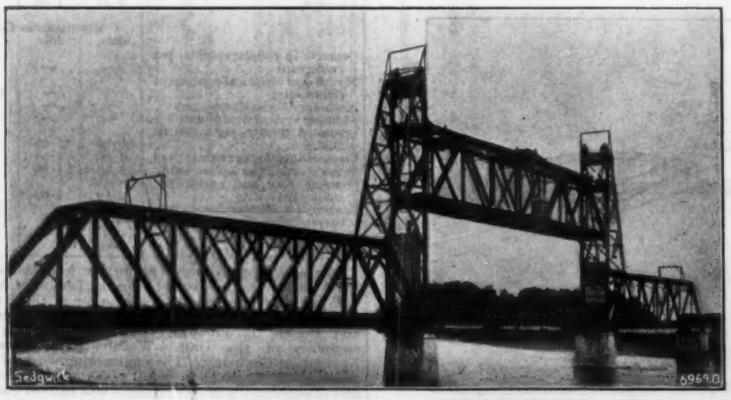

Fig. 16. Central Span of above Bridge made Operative.

Other Types of Lift Bridges.—To illustrate other contrasting types of vertical lift spans, in conclusion, Figs. 13 and 14 show a bridge built under great difficulties in Russia, and an inexpensive single-track girder span near Harrisburg, Tex., respectively. A single-track railway bridge for the Spokane, Portland, and Seattle Lines over the Willamette River, at Harrisburg, Ore., was originally built with three 200-ft. fixed spans and two 100-ft. half-through girders (Fig. 15) at a cost of 170,000 dols. It then marked the head of navigation on the river. Some years later the War Department directed that provision be made for river traffic. Machinery and lifting parts were added to the central span, towers to the adjacent spans, and the bridge was made operative, as shown in Fig. 16. This was done without interference with traffic. The cost (during the war period) of converting the fixed span into a movable bridge was 50,000 dols. The tower extensions above the sheaves are for power and telegraph wires.

CATALOGUES.

Electric Cables.—Very fully particularised lists of their paper-insulated cables, with full explanatory matter, has been issued in a special catalogue by the British Insulated and Helsby Cables, Limited, Prescot, Lancashire.

Bituminous Paint.—A catalogue and price list of their bituminous paints received from Messrs. Bowran and Co., Limited, 4, St. Nicholas Buildings, Newcastle-on-Tyne, mention that the paint is now made in red and green colours as well as black.

Shaping Machine.—A small shaping machine suitable for tool-room and precision work, is described in a catalogue received from the Butler Machine Tool Company, Limited, Halifax. The stroke is 8¼ in. and the feed traverse is on the worktable.

Power Plant.—An eight-page pamphlet, issued by Messrs. Daniel Adamson and Co., Limited, Dukinfield, Manchester, gives an interesting record of the activities of the late Mr. Daniel Adamson in developing the manufacture of boilers, engines and power plant generally.

Hydraulic Leathers.—An extremely useful little pamphlet of practical information on the selection and treatment of leather for hydraulic pumps has been issued by Leather Company (Altrincham), Limited, Altrincham, Manchester. Lists of standard ram, cup and hat leathers made to stock are included.

Bolts and Screws.—We have received from Messrs. James Wiley and Sons, Limited, Darlaston, some fully detailed and illustrated catalogues of bolts, studs, nuts, set screws, wood screws and various special forms of bolts, as well as catalogues of spanners and bright-drawn mild steel bars. In all cases standard prices are quoted.

Switch Gear.—A revised edition of his abridged catalogue of circuit breakers, alternating-current motor starting gear and crane control gear, has been issued by Mr. George Ellison, Perry Bar, Birmingham. The catalogue extends to 76 pages quarto, in a strong flexible cloth binding and gives the usual particulars and standard prices.

Transformers.—A handbook of instructions for erecting and operating their power transformers has been issued by the Metropolitan Vickers Electrical Company, Limited, Trafford Park, Manchester. It contains 32 pages of text and illustrations which deal in a clear and practical manner with all difficulties likely to be encountered.

Electrical Plant.—A new edition of a general catalogue of electrical plant including steam driven generator sets, turbo-generators, oil engines, gas-engine sets, water wheels, boilers, pumps, haulage gears, lifts and lifting magnets, has been issued by the General Electric Company, Limited, Kingsway, London, W.C. 2, together with a leaflet of revised prices.

Testing Machine.—Professor Haigh's alternating stress-testing machine is now being produced by Messrs. Bruntons, Musselburgh, who have issued a carefully-prepared catalogue containing full description, working instructions and example diagrams of test results on brass, aluminium, mild steel and Swedish iron. The machine was described in these columns, on page 866 of vol. cix.

Twist Drills.—Messrs. Alfred Herbert, Limited, Coventry, send a catalogue of Robertson's patent stepped twist drills, which will be especially useful for drilling through holes in plates. A small diameter is drilled first and a guide thus formed for successively larger diameters. Two to six steps are shown and a very large range of standard sizes are listed, the largest being capable of drilling holes 4 in. in diameter. The drills are of high-speed steel, with taper shanks.

Lifting Tackle.—A catalogue of chains, slings, hooks, anchors, anvils and similar work received from Messrs. Joseph Wright and Co., Limited, Tipton, Staffordshire, is of striking interest because of the large variety of simple appliances in which quality of material and workmanship dominate all other considerations; and also because of the frank warnings given that the best of such appliances may fail under improper use. The lists include practically all kinds of lifting, hauling and towing chains and the connections and other fittings used with them. The firm also undertakes the work of examining, testing and annealing chains at scale prices stated in the tables. A useful card stating the sizes of chain required for given loads on double slings, at various angles, is also issued by this firm in desk and wall sizes.